MAR 8 1923

PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXV.—No. 2982.] *LONDON: FRIDAY, FEBRUARY* 23, 1923. [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

Aveling & Porter, Ltd.,
ROCHESTER.
1103
Steam
Road Rollers & Tractors.

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement pages 24 and 25.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C. 2.
See half-page Advert. last week and next week. 675

Cranes.—Electric, Steam,
HYDRAULIC and HAND,
of all types and sizes.
GEORGE RUSSELL & CO., LTD.,
Motherwell, near Glasgow. 1137

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 1241
See Advertisement, page 9.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page* 76. 1293
Sole Makers: SPENCER-BONECOURT, LTD.,
Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD.,
ENGINEERS, NEWCASTLE-ON-TYNE. 1133

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 17. 1134

E. J. Davis, M.I.Mech.E.,
Gas Engines Inspected. Tested and Reported upon. Over 25 years' experience. Tel.: 736 and 737 Stratford. Wire: "Rapidising, London."
—Great Eastern Road, Stratford. E. 15. 1794

Brett's Patent Lifter Co.
LIMITED.
Hammers, Presses, Furnaces,
COVENTRY. 610

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9753

Electric Cranes.
1074
S. H. HEYWOOD & CO., LTD.,
REDDISH.

Fuller, Horsey, Sons & Cassell.
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C.3. 1834

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 60, Feb. 16.

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS,
SHALLOW DRAFT VESSELS.
318

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 12 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & Co., LTD.,
PORTSMOUTH.
SHIP & LAUNCH BUILDERS, Od 3351
ENGINEERS & BOILER MAKERS.

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest References. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 9769

OIL FUEL APPLIANCES,
Systems
PRESSURE, AIR, STEAM
For Boilers of all types,
KERMODES LIMITED,
35, The Temple, Dale Street, Liverpool.
Naval Outfits a Specialty,
also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
Telephone No.: Central 2832.
Telegrams: "Warmth." 4078

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od. 2487
See their Illus. Advertisement, page 89, last week.
RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS,
MOTHERWELL. Od 3383

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office: Od 8353
3, VICTORIA STREET, WESTMINSTER, S.W.

Henry Butcher & Co.,
AUCTIONEERS, VALUERS AND SURVEYORS
for
ENGINEERING AND ALLIED TRADES
and
INDUSTRIAL PROPERTIES. 9866
63 and 64, CHANCERY LANE, LONDON, W.C.2.

Electric Transporters.
S. H. HEYWOOD & CO., LTD., 1074
REDDISH.

John H. Wilson & Co. Ltd.,
Birkenhead.
See Illustrated Advertisement, page 83, Feb. 16.

Locomotive Shunting Cranes

Steam and Electric Cranes
EXCAVATORS, CRANE-NAVVIES, GRABS,
CONCRETE-MIXERS.
SHIPS' WINDLASSES, WINCHES, and
DECK MACHINERY. 637
LISTS OF STANDARD SIZES ON APPLICATION.
London Office 15, VICTORIA STREET, S.W. 1.

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW - BIRMINGHAM - LONDON.
See Advertisement Page 55. 1111

Suitable for Light Railway,
Tramway and General Power Transmission. A complete GENERATING PLANT of 1000 Kw. capacity is available for immediate delivery, comprising two 500 Kw. high-speed, enclosed, Compound Engines and Dick-Kerr Dynamos. 500/550 Volts D.C., Allen's Surface Condensing Plant, Edwards' and other Pumps, Baker Separator, piping, valves, &c., complete. Very low price—excellent condition. Also DIESEL ENGINES, 350/1200 HP.
JENNINGS, West Walls, Newcastle-on-Tyne. 978

Gearing for Power Transmission.
Including Machine Moulded GEAR WHEELS up to 10 feet dia.;
FLY WHEELS (rope or spur drive) up to 28 feet dia.;
IRON CASTINGS up to 15 tons each, in Loam, Dry or Green Sand;
ENGINES: "Uniflow," "Corliss" or Drop Valve.
BREAKDOWN Repairs a speciality.
CLAYTON, GOODFELLOW & CO., LTD.,
Atlas Works, BLACKBURN. 1249

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1234

SPECIFY WELDLESS STEEL CHAIN.
The Strongest Chain 898
IN THE WORLD.
Sole Manufacturers: WELDLESS CHAINS, LTD.,
50, WELLINGTON STREET, GLASGOW.

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C 3.
Works: BUNEY MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers.
&c., &c. 846

Electric Lifts
(UP TO 35 TONS.) 1074
S. H. HEYWOOD & CO., LTD.,
REDDISH.

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
London Office: 14, Leadenhall Street, E.C. Od 8382

Carels
Diesel & Steam
Engines.
CARELS DIESEL & STEAM ENGINES (LONDON), LTD.
Carlton House, Regent Street, London, S.W. 1.
Telephone: Regent 3484. 1120

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
Merrill's Patent TWIN STRAINERS for Pump Suctions. } ROW'S PATENTS.
SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5726

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS.
816

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, Dumbarton. 763
See Full Page Advt., page 61, Feb. 2.

Forgings.
Walter Somers, Limited,
HALESOWEN. 7116

Taylor & Challen
Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See half page advert., page 94, Feb. 2. 6196

Head, Wrightson & Co.,
LIMITED
See Advertisement page 58. 3402

Railway
Switches and
Crossings.
T. SUMMERSON & SONS, LIMITED,
DARLINGTON. 600

GRAPHITED OIL. GRAPHITED WATER.
"OILDAG" (Reg.) BRAND. "AQUADAG" (Reg.) BRAND.
GRAPHITED GREASE.
"GREDAG"
747
E. G. Acheson Ltd.,
Dept. E., (Sole Manufacturers). Works:
40, WOOD ST., S.W. 1. PLYMOUTH.

Locomotive Traversers
(ELECTRIC). 1074
S. H. HEYWOOD & CO., LTD.,
REDDISH.

P. & W. MacLellan, Ltd.,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 8547
Registered Offices: Clutha House, 10, Princes St., Westminster, S.W. 1.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND.
909
See half-page Advertisement, page 65, Feb. 16.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir WILLIAM FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 1311

The Royal Sanitary Institute.

PATRON—HIS MAJESTY THE KING.

EXAMINATIONS FOR SMOKE INSPECTORS.

The Syllabus includes the subjects necessary in order to carry out the duties of Smoke Inspectors. A knowledge of the administrative duties is required, and also practical experience in connection with the working of furnaces.
The Examinations are held in many centres throughout England, and full particulars may be obtained from the
SECRETARY.
90, Buckingham Palace Road,
London, S.W. 1. X 668

Correspondence Courses for

Inst. Civil Engrs., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., &c. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 56, SOUTH JOHN STREET, LIVERPOOL. 1295

American University Degrees

(Statutory). B.Sc., D.Sc., and B.Comm. obtained by Thesis written at home.—For particulars send self-addressed envelope (stamped), LAWRENCE (B.), Derwent Street, Leigh, Lancs. X 339

A Brochure describing our

Special Course of training in the lucrative field of "ENGINEERING SALESMANSHIP and SALES MANAGEMENT" will be sent on application to DIRECTOR, THE INSTITUTE OF ENGINEERING SALESMANSHIP, 333, Oxford Rd., Manchester. 1119

Powering of Vessels.—A

Practical Course of Instruction by Correspondence.—Address, for particulars and terms, 1049, Offices of ENGINEERING.

TENDERS.

EAST INDIAN RAILWAY.

The Directors are prepared to receive up to Eleven o'clock a.m. on Wednesday, the 14th March,

Tenders for the Supply of:—

(1) CORNISH and LANCASHIRE BOILERS.
(2) COVERED GOODS WAGONS.
Copies of the Specifications can be obtained at the Company's Offices on payment of £1 1s. each. This fee will not be returned.
G. H. LILLIE,
Secretary.
73-76, King William Street,
London, E.C. 4.
21st February, 1923. X 693

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

PRESTWOOD BOREHOLES.

CONTRACT No. 1.
TO BOREHOLE SINKERS.

The Chairman and Directors are prepared to receive

Tenders for Sinking Large

BOREHOLES on the site of the Prestwood Pumping Station at Stourton, near Stourbridge, in the County of Stafford.
Copies of Conditions of Contract, Specification with Form of Tender and Schedule of Quantities, may be obtained from the undersigned.
Sealed Tenders, addressed to me and endorsed "Tenders for Boreholes," must be delivered not later than Noon, Thursday the 15th March.
The Chairman and Directors do not bind themselves to accept the lowest or any Tender.
FRED. J. DIXON, M.Inst.C.B.,
Engineer.
Engineer's Office,
26a, Paradise Street,
Birmingham.
February, 1923. X 685

CORPORATION OF CALCUTTA.

NOTICE TO CONTRACTORS.

Tenders are Invited for the

SUPPLY, ERECTION and INSTALLATION of an AERIAL ROPEWAY for the removal of the City Refuse from the site of the motor lorry platform at Chingrighatta to the Square Mile.
Tenders should be submitted in duplicate and should be enclosed in a sealed cover superscribed "Tender for the Erection and Installation of an Aerial Ropeway," and should be addressed to the Deputy Chairman, Corporation of Calcutta, Central Municipal Office, 5, Corporation Street, Calcutta, and must reach him on or before the 30th April, 1923, when they will be opened in the presence of such tenderers or their accredited representatives as may be present.
Tenders must remain open for acceptance for at least three months from the date of opening.
For further particulars, if required, apply to the Chief Engineer, Corporation of Calcutta.
One set of the specification in duplicate with copies of plans may be obtained gratis from Messrs. The Indian and Eastern Engineer, 50, Fenchurch Street, London, E.C. 3.
The Corporation do not bind themselves to accept the lowest or any Tender.
JAMES R. COATS, B.Sc., M.Inst.C.E.,
Chief Engineer.
Central Municipal Office,
31st January, 1923. X 644

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

STEELWORK for BRIDGES for TINNEVELLY TIRUCHENDUR RAILWAY.
Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W. 1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked: "Tender for Steelwork for Bridges," must be left with the undersigned not later than Twelve Noon on Friday, the 16th March, 1923.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of 10s. for each copy of the Specification.
Copies of the Drawings may be obtained at the Offices of Messrs. ROBERT WHITE & PARTNERS, Consulting Engineers to the Company, 3, Victoria Street, Westminster, S.W. 1.
A. MUIRHEAD,
Managing Director.
91, Petty France, S.W. 1.
20th February, 1923. X 692

APPOINTMENTS OPEN.

COUNTY BOROUGH OF HALIFAX.

ELECTRICITY DEPARTMENT.

The Halifax Corporation have

Vacancies for the following

POSITIONS:—
Chief Assistant.
Station Superintendent.
Mains Superintendent.
Assistant Mains Superintendent.
Meter Test Room Superintendent.
Charge Engineers.
Applications, stating qualifications and salary required, to be sent to the undersigned not later than Ten o'clock a.m. on Monday next, the 26th instant.
By Order,
PERCY SAUNDERS,
Town Clerk.
Town Hall, Halifax,
20th February, 1923. X 683

Works Manager. — Appli-

cants for position advertised under Box No. X 464 are thanked for their replies, and are informed that the vacancy has now been filled. X 652

Manager Wanted for Foundry

employing 100/150 men in town within a radius of 25 miles of Glasgow; must have experience in production of high-class Castings for Land and Marine Engines; applications should state age, experience, salary desired and should include copies of references.—Address, X 660, Offices of ENGINEERING.

Wanted, Metallurgist for

large Manufacturing Plant in Scotland; must have had experience in research work and acquainted with modern methods of heat treatment of steel. State qualifications and last employer. Replies will be treated confidentially.—Address, METAL, WM. PORTEOUS & Co., Advertising Agents, Glasgow. X 673

Experienced Traveller Re-

QUIRED for London Firm manufacturing Boilers, Welded and Riveted Tanks, Jacket Pans, Buoys, Tar Stills, etc., also repairs to Boilers, etc., to follow up quotations and get new business. State full particulars and salary required.—Address, X 682, Offices of ENGINEERING.

Experienced Engineers' Prime

COST CLERK to take charge REQUIRED. Age, salary, particulars.—Address, X 676, Offices of ENGINEERING.

Wanted, Civil Engineer as

Assistant for maintenance of small Railway abroad. Knowledge of Spanish most desirable.—Write, giving full details of experience to C.E., care of STREETS, 30, Cornhill, E.C. 3. X 681

Engineer.—Wanted, Fully

Qualified YOUNG ENGINEER (preferably degree) to follow up enquiries and seek new business for Foundry and Engineering Works. Full time only. State salary required.—Address, X 680, Offices of ENGINEERING.

Estimating Engineer, com-

petent to handle enquiries and correspondence dealing with Air Compressors, Rock Drills and Pneumatic Tools, REQUIRED in London. State age, past experience and salary required.—Address, X 711, Offices of ENGINEERING.

Large Firm of Electrical

Manufacturers REQUIRE CHIEF ENGINEER for Switchgear Department. Must be thoroughly conversant with all Types of Switchgear, particularly A.C. and D.C. Starters and Control Gear.—Address, stating age, full particulars of qualifications and salary required, X 614, Offices of ENGINEERING.

Experienced Draughtsman

REQUIRED, having experience in Coke Oven and By-product Plants.—Address, stating experience and salary required, X 633, Offices of ENGINEERING.

A London Firm of Engineers

has a VACANCY for a Competent DRAUGHTSMAN well accustomed to Bridgework, Roofing, etc. State age, experience, and salary required.—Address, X 675, Offices of ENGINEERING.

Draughtsman, Capable,

REQUIRED for A.C. Machines.—Apply stating age, experience and salary required to ELECTRIC CONSTRUCTION CO., LTD., Wolverhampton. X 689

Wanted, by West of England

Firm, MECHANICAL DRAUGHTSMAN, with good experience in the design of Refrigerating Compressors, etc.—Address, giving full particulars of experience, age and salary required, X 708, Offices of ENGINEERING.

Crane Draughtsman Wanted,

with considerable experience in designing and detailing all types of cranework. Age 30 to 35. State age, experience, and salary required.—Address, X 705, Offices of ENGINEERING.

Draughtsman, Young, with

experience in FANS and FAN-WORK. State full experience and salary required.—STANDARD AND OSWALD STOTT, LTD., Leicester. X 701

Locomotive Draughtsmen

REQUIRED in Newcastle-on-Tyne. State experience, age, salary required. Only first-class men need apply.—Address, X 666, Offices of ENGINEERING.

Wanted Draughtsman, fully

qualified, used to Constructional Work, Headgears, and Screening Plants. Only first-class men need apply.
State full particulars and salary required by letter to—
GOODALL, CLAYTON & CO., LTD.,
Hunslet,
Leeds. X 700

Draughtsmen Wanted;

thoroughly experienced in the design of:—
(a) Heavy steel bridges, both fixed and movable.
(b) Steel caissons and gates for dock entrances.
(c) General dock and railway construction work.
Only men of the highest abilities in design and detailing of such work need apply.
Applications, stating age, salary required, and full particulars of training and experience and when at liberty, to be addressed to Box No. 2458, WILLINGS, 30, King Street, Covent Garden, W.C. 2. X 654

Chief Draughtsman Wanted

immediately, Centrifugal Pump Department, detail pump experience unnecessary if of wide general Engineering experience, including Foundry and Workshop practice. Must be able to control men, direct mechanical design and handle correspondence. State salary required. Only men of highest qualifications will be considered.—Reply by letter in own handwriting—MATHER & PLATT, LTD., EMPLOYMENT DEPARTMENT, Park Works, Manchester. X 657

Foreman for Gunmetal

FOUNDRY. Young, energetic, capable of making high class hydraulic castings and experienced with Moulding Machinery and up-to-date methods.—Address, X 551, Offices of ENGINEERING.

Steel Foundry.—Foreman

REQUIRED for Steel Foundry in Far East. Must be experienced moulder capable of taking full charge of Convertor Plant, and turning out all types of Alloy Steel Castings in collaboration with Metallurgic Chemist. Give full details of experience and send copies only of all references. Age not over 35; must be unmarried. Salary £38 per month, rising £36 per annum. Five years agreement; second class passage out and home.—Address, MOULDER, WM. PORTEOUS & Co., Advertising Agents, Glasgow. X 674

SITUATIONS WANTED.

Buyer.—The Manager of a

large Engineering Works Purchasing Department, who has an exceptionally wide knowledge of the markets of the Country, DESIRES to Negotiate NEW APPOINTMENT.—Write, Z.M. 613, care of DEACON'S, Leadenhall Street, E.C. 3. X 694

Manager (M.I.Mech.E.), 44,

DESIRES POSITION; Commercial and practical, General Engineering and Foundry experience.—Address, X 707, Offices of ENGINEERING.

English Representative Seeks

RE-ENGAGEMENT: Textile Machinery, Accessories, Yarns or similar specialities. Excellent connection. Fluent French and German; also good knowledge of Russian and Italian. First class references.—H. BARLOW, 280, Avenue Albert, Brussels, Belgium. X 444

Advertiser, Public School,

single, 28, three years' experience firm hydraulic engineers, including India, Seeks Responsible Position with good prospects with engineering firm. Initial salary desirable but not essential if employment in London.—Write B., 4825, WILLING'S, 33, Knightsbridge. X 665

Engineer-Draughtsman,

G.I.M.E. (passed A.M.I.M.E. exam.), age 26, 3½ years' shops, 5 years' drawing office experience in Marine and Land Engines, Diesel Engines, Pipe Arrangement Work, Water Tube Boilers, SEEKS POSITION of responsibility with opportunity for advancement.—Address, X 672, Offices of ENGINEERING.

Engineer, 31, with extensive

experience of design, erection and maintenance of works and factory plant—mechanical, chemical and electrical—Desires Responsible Post. Expert draughtsman.—Address, X 696, Offices of ENGINEERING.

Reinforced Concrete Engineer

with Continental and American practical and theoretical experience, SEEKS POST.—Address, X 710, Offices of ENGINEERING.

Engineer, over 20 years'

experience general marine and welding (oxy-acetylene and electric). Public School education. 4½ years' war service (Royal Fusiliers and Tank Corps), Desires Appointment in position of responsibility, home or abroad.—Address, X 703, Offices of ENGINEERING.

Heating Engineer, Theory and

Pract., SEEKS POST as Asst. Works Manager; 7 years' apprenticeship; previous experience, references.—Address, X 651, Offices of ENGINEERING.

Structural Engineer, highest

engineering degrees and several years' practical experience, SEEKS POST.—Address, X 709, Offices of ENGINEERING.

Consulting Marine Engineer,

A.M.I.C.E. and Naval Architect, established over 20 years London, DESIRES APPOINTMENT either as Representative in London of progressive shipbuilding and engineering firm, or technical Adviser to Merchants, or Superintending Engineer. Designs and Specifications prepared or criticised.
Address, X 702, Office of ENGINEERING.

Sound Practical Engineer (36),

Fluent Spanish, recently returned from S. America after completing installations of Hydro-Electric, Suction Gas, Steam Plants, and erection of Mining Machinery, SEEKS POSITION, Home or Abroad. Maintenance or Erection. Experienced in Water Power, Gas Producers, Oil and Gas Engines, Steel Structures, River Transport, Marine and Shop. Capable of controlling large bodies of labour.—Address, X 697, Offices of ENGINEERING.

University Graduate, B.Sc.

Hons. Civil Eng. (23), Desires Suitable Opening with prospects. Good references.—Write, G.R., 11, Albany Place, Plymouth. X 686

Draughtsman or Asst. Manager

for Rolling Stock, Mechanical, Electrical, or Structural and General Engine Design and Details. 5 yrs. Wks. and 10 yrs. D.O. Age 31.—Address, X 699, Offices of ENGINEERING.

Mechanical Draughtsman (31)

SEEKS SITUATION—quick and accurate, 16 years' engineering and foundry experience, estimating and costing, moderate salary.—Address, X 704, Offices of ENGINEERING.

Advertiser Urgently Requires

POST, any reasonable capacity. Gentleman, educated, 32, married. Responsible Position in Factory, Assistant Works Manager, or similar post, where engineering training, capacity for figures and correspondence, and thorough reliability of use. Held positions as Asst. Engineer. Good references. Prospects and permanency desired. War service.—Address, X 650, Offices of ENGINEERING.

PARTNERSHIPS.

Engineering Partnerships

AND
BUSINESSES.

Wheatley Kirk, Price & Co.

46, Watling Street,
LONDON, E.C. 4.
ESTABLISHED SEVENTY YEARS. 1114

Partnerships, Directorships.

—We have a large number of men, fully qualified and experienced, who have £10,000, £8000, £7000, £5000, £3000, £2000 to invest. We want well-established businesses able to give immediate incomes. We print a paper, "The Business Broker," free, to bring investors and investments together.—OFFICERS' PARTNERSHIP GUARDIAN, LTD., 48, Dover Street, W.1. For all educated men. Call. X 669

Wanted, a few Gentlemen

well up in Steel Foundry work, to join together for purchase of an existing old-established business in the Midlands; plenty of room for developments and extensions. State experience, whether practical or commercial, and capital available.—Address, X 699, Offices of ENGINEERING.

PATENT AGENTS.

Patents DESIGNS AND TRADE MARKS IN ALL COUNTRIES.

E. P. Alexander & Son,

CHARTERED PATENT AGENTS,
308, HIGH HOLBORN, LONDON, W.C.
(Established 1874.)
Telephone: Central 7434. Cd 869

Phone—Holb. 541. Tele.—Andrubo, Holb., London.

Andrews & Beaumont,

CHARTERED PATENT AGENTS, 915
29, Southampton Buildings, London, W.C. 2.

Patents and Trademarks:—

Inventors Advice, Handbook and Consultations free.—KINGS PATENT AGENCY, LTD. (B. T. King, Director), 146a, Queen Victoria Street, London. 36 years' refs. 1309

WANTED, &c.

J. Kirkaldy, Limited.

WORKS,
BURNT MILL, ESSEX. 1286

We are organised to produce castings from 2 lbs. to 2 tons. Cast-iron, Semi-steel, and Non-ferrous castings. Coils of every description, Steel and Copper. Sheet Metal Work. Over 40 years' experience is at your service. Send your enquiries along.

Rosser and Russell, Ltd.,

MECHANICAL ENGINEERS.
QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
Phone: Hammersmith 31, 967. 2211

18-IN. REFRACTING TELESCOPE FOR THE BRAZILIAN GOVERNMENT.

(*Concluded from page* 162.)

TURNING now our attention to the optical parts of the instrument, the large objective of 18-in. aperture, which is shown in section in its metal cell in Fig. 39, and half elevation in Fig. 40, on Plate XVI, has a focal length of 21 ft. 2 in. from the rear surface of the double-concave flint lens, and the total thickness of the centres of the lenses is about 2·7 in. In the case of large objectives of over 1 ft. aperture the lenses are generally somewhat thinner relatively to their aperture than smaller objectives, and the question of mechanical flexure under the action of gravitation has to be guarded against.

The flint lens rests upon three fixed points of support, 120 deg. apart, in the cell, and at each of those points there is a pad of tinfoil cemented on the edge of the flint lens; on these pads the crown lens rests. If the telescope be pointed towards the zenith, then the weight of the lenses causes them to sag down along their radii lying between the three points of support. This sagging causes a triangular conformation of the star image, this being chiefly through its influence on the lower flint-glass lens. In order to overcome this sagging three weighted levers are employed. These are shown in elevation in Fig. 40, while Fig. 41 is a radial section showing how the ends of the levers lift up the two lenses by their edges. The weights are so adjusted as to give a lifting pressure equal to one-sixth part of the weight of each lens. Also, the levers work in two directions, they give the same pressure of one-sixth of the weight of the lenses in the plane of the lenses or towards their centres when the telescope is laid horizontally and the direction of gravitation is in the plane of the lenses. This relieves by one-half the great pressure of the lenses upon the fixed points of support. It will easily be seen that the action of these levers is quite automatic, so that the strains due to the action of gravity upon the lenses in their plane or at right angles to that plane are always counteracted in their proper relative proportions, in whatever position the telescope may be placed. The magnifying powers that the telescope will bear vary between 100 and 1,000, according to the stability and transparency of the atmosphere, which latter is generally a great obstacle in the way of clear seeing with very large telescopes unless they are erected at exceptionally high elevations.

Besides the principal 18-in. object-glass, a 12-in. aperture guiding telescope and a 5-in. aperture finder telescope, the telescope also carries, attached to it on either side, two astro-photo Cooke lenses of 10-in. aperture and about 67 in. equivalent focal length, for photography of the stars. The lenses are mounted on cameras carrying photographic plates 12 in. square, so that to the corners of such plates

Fig. 61.

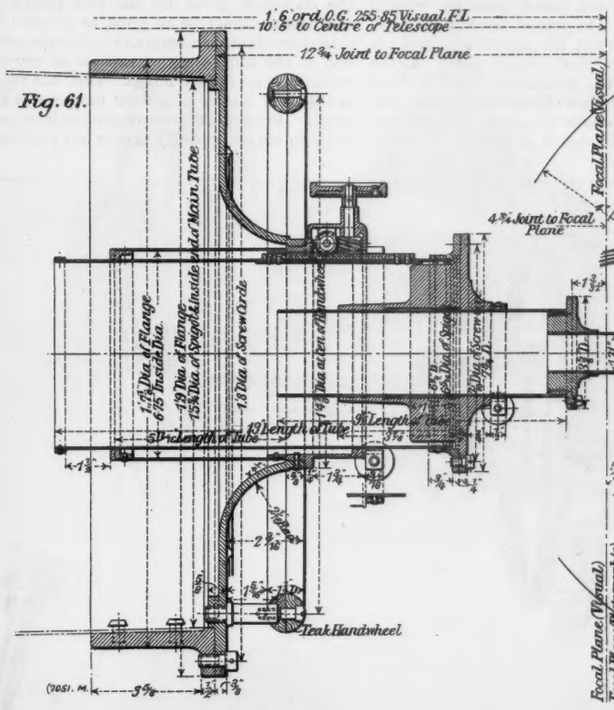
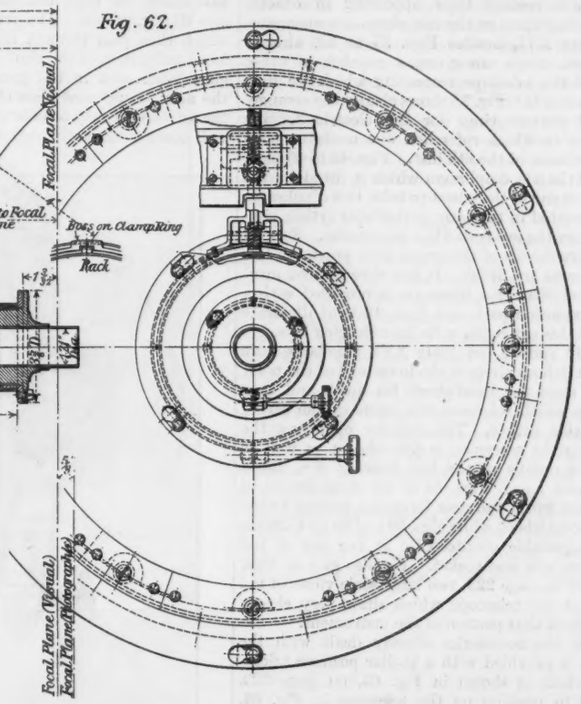


Fig. 62.



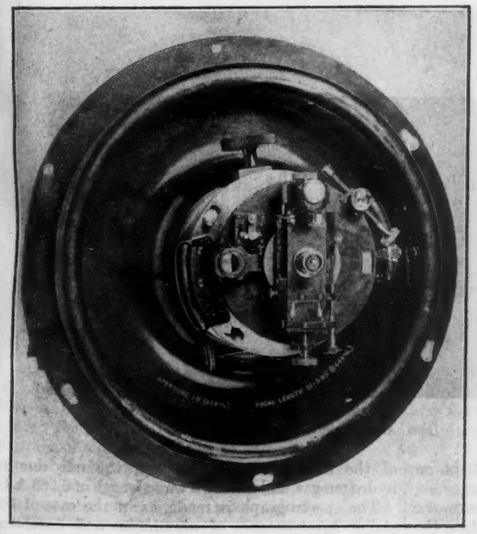


FIG. 63.

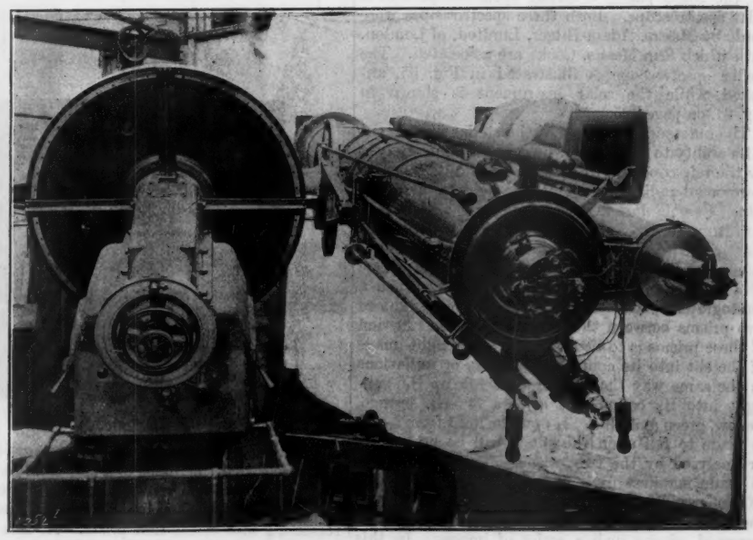


FIG. 64.

a square field of 14 deg. extent is taken in. The taking of such stellar photographs in duplicate, affords a ready means, by comparison between corresponding parts of any pairs of duplicate plates or of positives taken from them, of determining whether certain dubious star images are genuine star images or whether they have been caused by defects or specks of dust on the plates. If the latter, then the chances against their appearing in exactly corresponding spots on the two plates are enormous.

On Plate XVI, besides Figs. 38 to 42, already referred to, there are given a number of other details of the telescope respecting which we may say a few words. Fig. 38 shows clearly the arrangements of contact rings for the electric lighting equipment to which reference was made on page 161 of our issue of the 9th inst. Figs. 43 to 46 show details of the iris diaphragm which is fitted to the object-glass end of the telescope tube, this diaphragm being, as stated in the early part of this article, controlled from the eye end of the instrument. Figs. 47 and 48 give details of the lenses with which the two astro-cameras are fitted. It has already been mentioned that the main telescope is provided with a camera extension part, and Figs. 49 to 51 illustrate details of this extension with the enlarging lens.

Figs. 52 and 53, on Plate XVI, give large-scale views of the hour circle at the lower end of the polar axis and show the handwheels for quick and slow setting to which reference was made in the earlier part of this article. The rod for operating the clamp in right ascension is also shown as well as interesting details of the ball bearing, &c., fitted to the polar axis. Figs. 54 to 58 show details of the tangent worm and gear for giving motion to the main-driving wheel, while Figs. 59 and 60 give details of the adjustable counterpoise at the end of the declination axis and socket. We also give in Figs. 61 and 62, on page 223, two large-scale views of the eye-end of the telescope which show very clearly the details of that portion of the instrument.

Besides the accessories already dealt with the telescope is provided with a bi-filar position micrometer (which is shown in Fig. 63, on page 223, and also in position on the telescope in Fig. 64, on the same page), a stellar spectroscope and a solar spectroscope. Both these spectroscopes were made by Messrs. Adam Hilger, Limited, of London, with which firm Messrs. Cooke are associated. The stellar spectroscope is illustrated in Fig. 65, annexed, while the solar instrument is shown in Fig. 67, on page 225.

The outstanding feature of the stellar instrument is its ability to utilise the whole of the light received by the telescope and to break it up into its separate component radiations. Thus the light from a star, which light is due, say, to hydrogen gas, is broken up into a series of radiations peculiar to hydrogen spectra. These spectra are obtained in the following manner: By a system of two lenses the image of a narrow slit of white light is focussed upon a photographic plate. Into this system are introduced two prisms between the two lenses. The function of these prisms is to break up the white light image of the slit into its component colours or radiations in the same way that raindrops break up the sunlight into its component colours of red, orange, yellow, green and blue. If now the light from a star is made to fall upon the slit it will be broken up or analysed by the two prisms. This breaking-up is made manifest by a series of horizontal images of the narrow slit, each representing one definite radiation of one definite wave-length. Fig. 66, annexed, shows such a series of images. In this case the light from a copper arc has been analysed.*

The wave-lengths of these images can be computed by the astronomer from the exact position of each upon the photographic plate, and from such data the gas of which the star is composed can be determined with certainty. The spectrum also gives (by the observation of other characteristics of the slit image) valuable information relative to the class or series to which a star belongs, its age and relative velocity in space.

Next as to the construction of the instrument. The body is made as light as possible (aluminium being largely used), and is secured by three parallel pillars to the flange which attaches to the telescope. The slit, upon which the image of the star is thrown, is made of non-tarnishable metal. It is composed of two jaws, one fixed and the other movable within a slide by means of a micrometer screw. The slit can thus be adjusted to any desired width.

The light passing through the slit is received by a lens of aperture ratio F 5, which collimates or parallelises the rays and passes them on through two 60-deg. prisms. The prisms disperse the rays, which then pass through the second lens and are focussed by it on to the photographic plate. All the glass work used in the instrument is made from the most transparent glass obtainable in order that the astronomer may be able to examine the spectrum well down towards the region of the invisible rays.

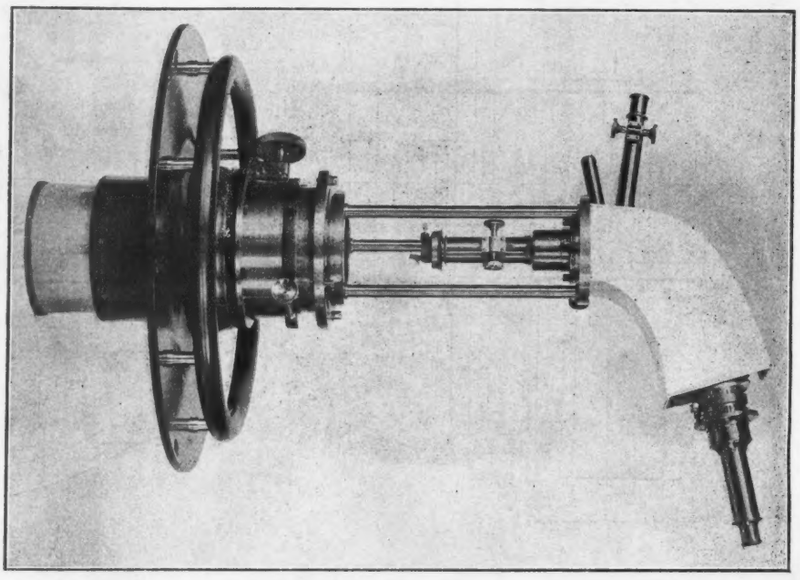


FIG. 65.

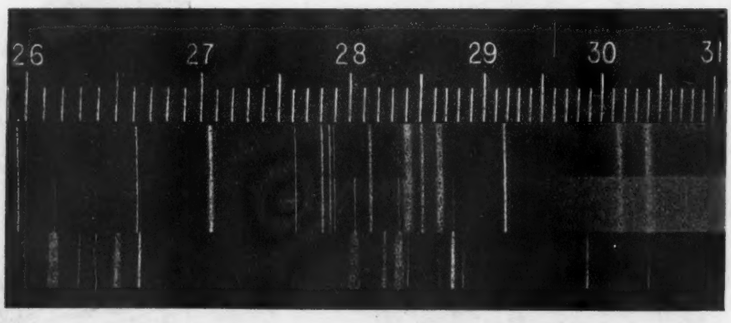


FIG. 66.

In order that the image of a star shall be kept on the narrow slit through a lengthy time exposure, a small observing telescope is fixed opposite the refracting face of the first prism. At this face the greater part of the light from the slit is refracted and passes on towards the photographic plate, but a small percentage is also reflected from this face, and by utilising this beam another image of the slit can be seen in the small observing telescope, and the driving mechanism of the main telescope accelerated or retarded to keep the star, as seen in the observatory telescope, continually on the same part of the slit.

In addition to the stellar spectroscope the telescope is, as already mentioned, provided with a second instrument known as an Evershed solar prominence spectrograph, also made by Messrs. Adam Hilger, Limited. This instrument, which is illustrated in Fig. 67, on page 225, is named after Professor J. Evershed, of the Solar Physics Observatory, Kodaikanal, India. Messrs. Hilger first made such an instrument for Professor Evershed many years ago to carry on with increased efficiency the pioneer work of the late Sir W. Higgins and Sir Norman Lockyer in the study of the character of the high outbursts of hydrogen from the limb of the sun known as solar prominences.

For many technical reasons it is desirable that the dispersion given by the two prisms in this instrument should be as great as possible in consideration of the maximum size and weight allowable, and at the same time be capable of transmitting an undistorted optical image. This, one might say, is the chief feature of a solar prominence spectrograph. Briefly, this great dispersion is necessary in order to very completely isolate one particular line of the solar spectrum, namely, the one due to hydrogen gas, and having a wave-length of 6,563 A.U.

The spectrograph is made, as in the case of the stellar spectroscope, of aluminuim and duralium, and constructed as lightly as possible. Within the pentagonal-shaped aluminium box are fixed the large compound prisms, each composed of three cemented components, of which one is constructed from a very extra-heavy dense flint glass of extremely high refractive index. Each individual prism has a dispersion between A and H Fraunhofer lines of the solar spectrum of 30 deg., making a total of 60 deg. for the two prisms. (It is interesting to note that the dispersion between the same two lines, as given by the stellar spectroscope, is only about 2 deg.)

For the sake of compactness, the light, when emerging from the first prism (the lower one of the two inside the pentagonal box in the illustration), is reflected back by a mirror into the

* This figure is three times the scale of the actual spectrograph.

second prism (the upper one inside the box). The adjustment of this mirror also serves as a convenient and accurate means of bringing any particular portion of the solar spectrum into the centre of the photographic plate. For this purpose the mirror is mounted upon a swivelling table, whose centre coincides with the plane of the reflecting surface; the whole mirror and mount are then moved by means of a micrometer-screw and vernier.

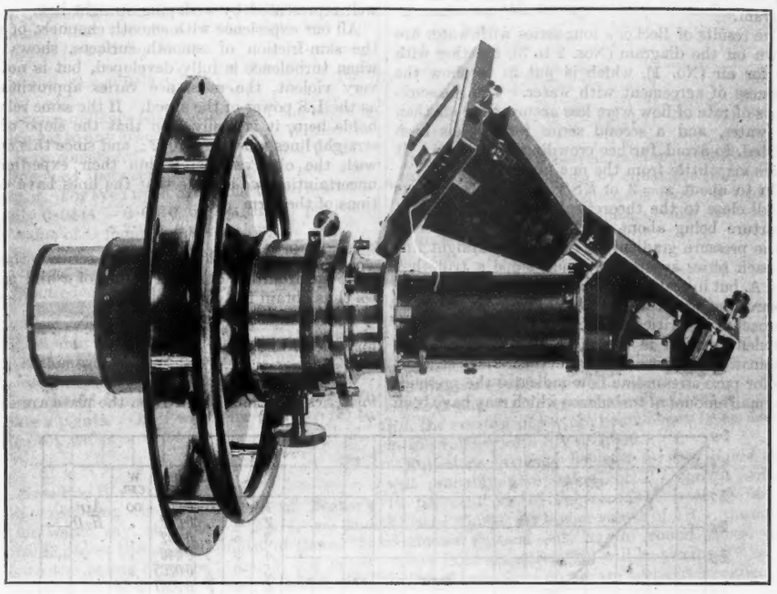


FIG. 67.

The working principles of the instrument are the same as previously described in the case of the stellar spectroscope. The image of the desired portion of the sun is projected upon the slit of the instrument, the adjusting screw of which can be seen projecting from the left-hand side of the large tube supporting the prism box. The light then passes successively through the collimator lens, seen projecting from the bottom of the box, the first prism, the swivelling mirror, the second prism, and then the camera lens which finally throws the image of the slit or prominence upon the photographic plate.

The main body of the instrument is fitted with a circular rack and pinion by which it can be rotated through 360 deg. about the axis of the main telescope. It is, therefore, apparent that if the spectrograph as a whole is mounted eccentrically by an amount equal to the mean radius of the sun's image, its axis will describe a circle about the axis of the main telescope, equal in diameter to the sun's image, and the slit will move tangentially to the limb of the sun.

By these means any selected part of the sun's limb can be examined at will, and if a prominence is active at that part it will be seen occupying the exact position in the spectrograph as the hydrogen line 6,463 A.U., or any other of the prominent hydrogen lines. By exposing the photographic plate to the image of the prominence, a permanent record is obtained.

To facilitate the search for and the observation of a prominence, the slit jaws of the spectroscope are not straight as in the case of the stellar spectroscope, but are made circular upon the edges by an amount equal to the mean radius of the image of the sun as given by the main telescope to which it is attached.

A further use of this instrument is the examination of the corona, and to a lesser extent the spectra of the well-known sun spots. These observations are made by adjusting the correct portion of the solar image coincident with the spectrograph slit, which in these cases is the ordinary straight-jawed slit.

Lastly, a few words may be said about the dome in which the telescope we have been describing is mounted, and of which we give a small view in Fig. 68, annexed. This has a hemispherical shell 33 ft. 6 in. diameter and consists of a covering of thick *papier-mâché* panels, copper-riveted to a frame of steel T's stiffened by angles. The whole is carried on a stiff base ring of box section cast in segments and bolted together. The ring carries large turned rollers with steel spindles running in ball bearings. The rollers run on a cast-iron rail bolted to the top of the observatory wall.

One of the rollers is mounted in an independent frame with vertical spring adjustment by which pressure can be applied to produce sufficient friction between the roller and the rail to enable the dome to be revolved, or, in other words, that roller can be made to take much more than its own share of the dome weight so that, when the roller is rotated by the endless rope hand gear provided, the roller bites the rail and the dome revolves. The device acts admirably and avoids the noise that usually attends a large circular, toothed rack and pinion with cast teeth.

On account of the large angle of rays taken in by the two cameras and telescopes combined, a specially wide opening is required in the dome. This is 10 ft. 6 in. wide at the base and 7 ft. wide at the zenith. Two shutters cover the opening. Both are opened and closed by endless ropes worked from the inside. Each shutter frame is carried right down the other side of the dome to a fixed socket in which it pivots, and at the front or opening side is carried on corner rollers running on a fixed rail. There are also supporting rollers at the crown. Horizontal rollers carried on the main base-ring of the dome and acting against the edge of the foundation rail, take all side and wind pressure.

Although the weight of the dome is over 10½ tons, a pull of 15 lb. on the hand-rope sufficed to put it in motion when erected in the makers' works, and 8 lb. to keep it moving. The total weight of the telescope and mounting is about 8 tons. In conclusion we give, in Fig. 69, a general view of the Observatorio Nacional, at Rio de Janeiro.

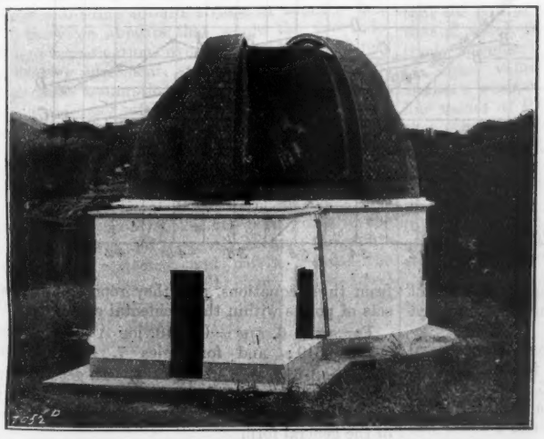


FIG. 68.

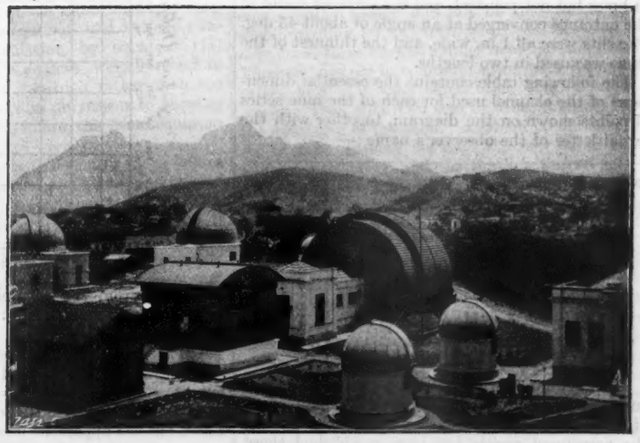


FIG. 69.

LEAKAGE THROUGH THIN CLEARANCE SPACES.*

By EDGAR BUCKINGHAM.

1. *Introduction.*—In 1907, E. Becker† published the results of experiments on the flow of water, air and steam along thin annular slits between co-axial cylinders. Most of the observations were

* The occasion for this paper was given by Mr. Frank F. Fergusson's communicating his experimental results to me by letter, and it would have been natural for us to publish the paper jointly. But since circumstances make ready communication between us impracticable, it has seemed better that I should take the responsibility for the form in which the material is presented, leaving Mr. Fergusson free to comment or criticise, independently. Acknowledgment is due to Messrs. R. Blakeborough and Sons, of Brighouse, Yorkshire, for their liberality in providing the apparatus and equipment needed for Mr. Fergusson's experiments. E. B.

† *Forsch. arb., No.* 48, and *Zeitschr. V.D.I.*, 51 II, page 1,133, 1907.

in the region of stream-line flow, and it is desirable that the range of experiment be extended to higher speeds, because, in practice, leakage through such clearance spaces will often be far up in the region of turbulent flow. Pending such further work, advantage may be taken of the results of some recent experiments on slits of rectangular section by Mr. Frank F. Fergusson, which he has kindly placed at my disposal for presentation here. These permit of a very probable extrapolation of Becker's results to considerably higher speeds of flow.

2. *Notation.*—The following notation will be used :

D (cm.) = outside diameter of annular slit.
w (cm.) = width of flat slit.
h (cm.) = thickness of slit.
l (cm.) = distance between side holes for gauge connections.
m (cm.) = distance from entrance to first side hole.
S (cm. sec.$^{-1}$) = mean linear speed of flow along the slit.
P (dyne cm.$^{-2}$) = pressure drop in the length l.
G (dyne cm.$^{-3}$) = P/l = pressure gradient.
μ (gm. cm.$^{-1}$ sec.$^{-1}$) = viscosity of the fluid.
ρ (gm. cm.$^{-3}$) = density of the fluid.
ν (cm.^{2} sec.$^{-1}$) = μ/ρ = kinematic viscosity.
$x = \log_{10}(h\,S/\nu)$, $y = \log_{10}(h\,G/\rho\,S^2)$ } co-ordinates used for plotting points on the plate.

The C.G.S. units are convenient because of the ease of finding tables of viscosity and density in that system, but all the quantities may equally well be expressed in any other set of normal units, such as the foot, second, pound—mass system.

3. *Dimensions of the apparatus.*—Becker used two different hollow cylinders, each provided with two cylindrical plugs which could be centred in it, so that there were four annular channels in all. The surfaces were ground, but it is not stated that they were polished. The ends of the plugs were slightly rounded off, to remove the sharp corners. Fergusson's rectangular slits were smoothly machined in brass but not polished, and the surfaces ahead of the entrance converged at an angle of about 45 deg. The slits were all 1 in. wide, and the thinnest of the three was used in two lengths.

The following table contains the essential dimensions of the channel used for each of the nine series of points shown on the diagram, together with the initial letter of the observer's name :—

No.	—	D.	w.	h.	l.	m.	$\frac{m}{h}$
		cm.	cm.	cm.	cm.	cm.	
1	B	2·204	∞	0·062	17·5	1·4	23
2	B	2·204	∞	0·062	17·5	1·4	23
3	B	2·204	∞	0·042	17·5	1·4	33
4	B	2·400	∞	0·040	18·0	1·0	25
5	B	2·400	∞	0·0205	18·0	1·0	49
6	F	∞	2·54	0·0787	27·77	1·0	13
7	F	∞	2·54	0·0375	27·77	1·0	27
8	F	∞	2·54	0·0114	27·77	1·0	88
9	F	∞	2·54	0·0114	15·15	1·0	88

With cylindrical tubes, it is necessary to have an entrance length of 100 diameters or more ahead of the first pressure tap, in order to make sure that the permanent *regime* has been established there, and it may be surmised that the values of m/h given above were hardly sufficient for this purpose, except perhaps at the lower speeds.

It is evident that when the thickness of an annular slit is very small in comparison with its mean diameter, as in Becker's experiments, the resistance of the slit per unit width will be sensibly the same as for a plane slit with no edges. We shall therefore treat the annulus as part of an infinitely wide rectangle and shall co-ordinate the data on rectangular slits of finite width with those on ring slits, by making an allowance for the effect of the edges.

4. *Stream-Line Flow.*—The equation for stream-line flow along an infinitely wide plane slit is

$$S = \frac{G\,h^2}{12\,\mu} \quad . \quad . \quad . \quad . \quad (1)$$

It differs from the equation for a tube of diameter d, only in having $h^2/12$ in place of $d^2/32$, and it may readily be deduced by the same elementary methods. There is no difficulty in deducing the equation for an annulus,* but the equation is inconvenient when the slit is very thin, and it is then sensibly equivalent to equation (1).

* See, for example, Lamb's "Hydrodynamics," fourth edition, page 579.

Equation (1) may be written in the form

$$\frac{h\,G}{\rho\,S^2} = 12\,\frac{\nu}{h\,S} \quad . \quad . \quad . \quad (2)$$

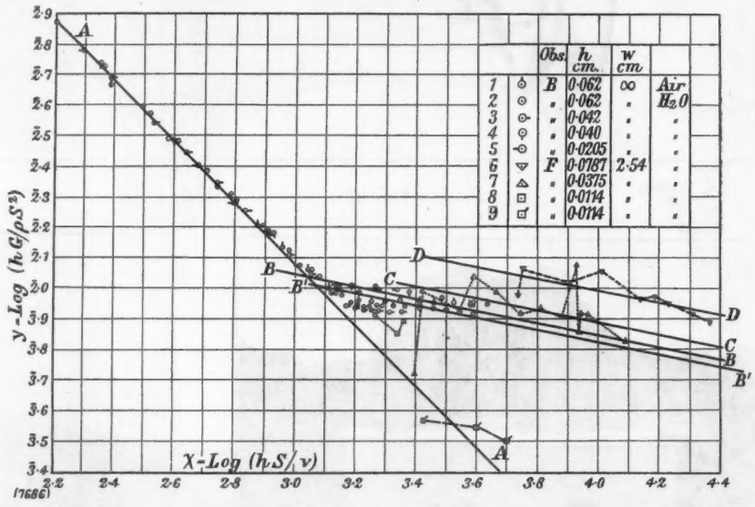
or

$$y = 1{\cdot}079 - x \quad . \quad . \quad . \quad (A)$$

and this equation is represented by line A on the diagram.

The results of Becker's four series with water are shown on the diagram (Nos. 2 to 5), together with one for air (No. 1), which is put in to show the closeness of agreement with water. The measurements of rate of flow were less accurate for air than for water, and a second series for air has been omitted, to avoid further crowding the points. It differs very little from the one given.

Up to about $x = 3$ or $h\,S/\nu = 1{,}000$, the points are all close to the theoretical line A, the greatest departure being about 0·02 in y, or 5 per cent. in the pressure gradient G. The best straight line for each series separately would slope a trifle less than A, but in reality the curves are slightly concave upward, the departure from A increasing as the speed approaches the critical or limiting value above which turbulent motion is the more stable state. This systematic departure from the theoretical straight line for pure stream-line flow indicates the presence of a small amount of turbulence which may have been



a survival from the entrance, due to insufficient length of the preliminary run ahead of the first pressure tap.

5. *The Change to Turbulent Flow.*—The critical point is less sharply marked than for round tubes, but it comes between $x = 3{\cdot}05$ and 3·15, or $h\,S/\nu = 1{,}120$ and 1,430. Series 2 and 3 give about 1,380, but the apparatus used in series 4 and 5 was more accurately made, and these series give more nearly $x = 3{\cdot}1$ or $h\,S/\nu = 1{,}260$. These values may be compared with that for a round tube of diameter d which is* $d\,S/\nu = 2{,}320$, when there is great initial turbulence and a sufficient preliminary run ahead of the first side hole.

Above the critical speed, the curve changes in somewhat the same way as for round tubes, but the familiar dip and sudden rise to a maximum are only faintly indicated ; and it appears that in the absence of the restraining effect of edges, turbulence comes on not only earlier but much more gradually than in a tube of diameter $d = h$.

The maximum, which we may suppose to indicate that turbulence is fully developed, comes in the vicinity of $x = 3{\cdot}4$, and at this point the ratio of turbulent to stream-line resistance is about the same as in a tube of diameter $d = h$, at the same value of S/ν.

Above the critical region the curve begins to fall, but Becker's observations do not go much farther, so we may attempt to supplement them by Fergusson's observations, which are next to be considered.

6. *Thin Rectangular Slits.*—The points of series 6 to 9 represent Fergusson's results. On account of the less favourable working conditions, the accidental errors are evidently much greater than in Becker's experiments ; but while the points are somewhat scattered, their general run, for each of the two thicker slits (series 6 and 7), may be tolerably well represented by a sloping straight line.

All our experience with smooth channels, or with the skin-friction of smooth surfaces, shows that when turbulence is fully developed, but is not yet very violent, the resistance varies approximately as the 1·8 power of the speed. If the same relation holds here, it is easily seen that the slope of the straight lines must be $-0{\cdot}2$; and since this agrees with the observations, within their experimental uncertainties, we assume that the lines have equations of the form

$$y = \log A - 0{\cdot}2\,x \quad . \quad . \quad . \quad (3)$$

The best value of log A for each series is then to be found from the observed values of x and y, and we thus obtain the equations

$$y = \bar{2}{\cdot}685 - 0{\cdot}2\,x \quad . \quad . \quad . \quad (C)$$

for series 7 and

$$y = \bar{2}{\cdot}792 - 0{\cdot}2\,x \quad . \quad . \quad . \quad (D)$$

for series 6. Lines C and D on the plate are drawn from these equations, and they represent the two sets of points within the accidental errors.

For series 6, $h/w = 0{\cdot}0310$, log A = $\bar{2}{\cdot}792$, and A = 0·0619 ; and for series 7, $h/w = 0{\cdot}0148$, log A = $\bar{2}{\cdot}685$, and A = 0·0484. To get a general equation which shall hold for any small value of the thickness ratio h/w, we must use an expression of the general form

$$A = a + f\left(\frac{h}{w}\right) \quad . \quad . \quad . \quad (4)$$

in which a is the limiting value of A for an infinitely wide slit, and $f(h/w)$ represents the modification due to the edges. We have next to assume some form for f.

At each edge of a wide slit, the circumstances of the fluid motion are somewhat like those in a square channel, and it seems likely that the influence of the edge will extend inward to a distance which is not constant and independent of the length of the edge h but more nearly proportional to it. If this is so, the fraction of the whole cross-section of the slit within which the flow is sensibly modified by the presence of the edges, will be proportional to $(h/w)^2$, and, following this somewhat superficial reasoning, we assume that equation (4) has the more specific form

$$A = \alpha + \beta\left(\frac{h}{w}\right)^2 \quad . \quad . \quad . \quad (5)$$

Upon determining the values of α and β from those of A, already found for series 6 and 7, we have for any very thin wide slit

$$A = 0{\cdot}0444 + 18{\cdot}2\left(\frac{h}{w}\right)^2 \quad . \quad . \quad (6)$$

And for actual computation, equation (3) may be

* See L. Schiller, *Physikal. Zeitschr.* 23, page 14, January 1, 1922.

put into the more convenient form

$$\left.\begin{aligned}\frac{P}{l} &= A\,\frac{\rho\,S^2}{h}\left(\frac{\nu}{h\,S}\right)^{0\cdot2}\\ &= A\,\frac{\rho^{0\cdot8}\,\mu^{0\cdot2}\,S^{1\cdot8}}{h^{1\cdot2}}\end{aligned}\right\} \quad . \quad . \quad . \quad (7)$$

where A is to be found by equation (6) from the known value of h/w for the slit in question.

Assuming that the effect of the edges was proportional to $(h/w)^{1\cdot5}$ would give

$$A^1 = 0\cdot0416 + 3\cdot69\left(\frac{h}{w}\right)^{1\cdot5} \quad . \quad . \quad (8)$$

and it seems unlikely that the effect of the edges is proportional to any lower power of h/w. Within the range here considered, namely $0 < h/w < 0\cdot0310$, the difference between A and A^1 is not very important. For even upon extrapolation to $h/w = 0$, it is only $0\cdot0444 - 0\cdot0416$, or less than 7 per cent. in the value of G found from equation (7).

7. *Comparison with Annular Slits.*—A thin annular slit of large radius being equivalent to a plane slit without edges, equation (3) with $A = 0\cdot0444$, or

$$y = 2\cdot647 - 0\cdot2\,x \quad . \quad . \quad . \quad (B)$$

should, on our assumptions, represent the results which Becker would have obtained if he had used higher rates of flow; and line B, drawn from this equation, should form a continuation of the curve of Becker's points. Or, if we prefer equation (8) to equation (6), we have

$$y = 2\cdot619 - 0\cdot2\,x \quad . \quad . \quad . \quad (B^1)$$

which gives line B^1 on the diagram.

Upon examining the later points of Becker's series for water, say, those for $x > 3\cdot4$, we find that line B passes through the midst of them. It lies above the points of series 2 and 3, but below and nearer to those of series 4 and 5, which were taken with the more accurately constructed channels. Line B^1 is distinctly too low down. Furthermore, curves for Becker's separate series on water are evidently tending toward a slope of about $-0\cdot2$.

It therefore appears that where the two independent investigations overlap, they are in entirely satisfactory agreement, and that line B, obtained on plausible assumptions from Fergusson's observations alone, may safely be used to extend Becker's data on annular channels. Its equation may probably be relied on within 10 per cent. or 15 per cent. for computing the resistance of such channels up to at least $x = 4\cdot4$ or $h\,S/\nu = 25{,}000$.

8. *Some Exceptional Points.*—In analysing Fergusson's data, no attention has been given to the points of series 8 and 9—partly because the points are few and scattered, and partly because the measured thickness, $h = 0\cdot0114$ cm., was so small that there is, unavoidably, a large percentage uncertainty in its value and in the values of x and y which depend on it.

The three points of series 9 fall near line A instead of near line B as would be expected, and it is evident that stream-line motion persisted up to a speed at which turbulence would normally have set in. This phenomenon is familiar in the case of smooth round tubes, and its occurrence here shows that the resistance of a smooth thin channel with an easy entrance may be much less than indicated by equations (3) and (6), and the leakage much greater. This could doubtless be avoided by using a sharp entrance or sharp edged labyrinth grooves.

The three points of series 8 are also lower than line B or than any of Becker's points. If their location has any significance, it suggests that the presence of edges tends to delay the onset of turbulence and make the curve more like that for round tubes.

One point of series 7 lies close to line A, and this was evidently another case of the persistence of stream-line flow. The break to the next point comes at $h\,S/\nu = 2{,}500$, or not far from the critical point for a tube of diameter $d = h$.

9. *Equations for Computing the Resistance of Thin, Smooth, Annular Channels.*—Examination of the plate leads to the following conclusions:—

(*a*) For $x < 3\cdot05$, line A represents all the observations on both air and water within about $0\cdot027$ in y, nearly all the points being above the line.

(*b*) For $x > 3\cdot05$, line B represents Becker's series 4 and 5, which are presumably the most accurate, within $\pm 0\cdot025$ in y. The points for the less accurate series 2 and 3 are systematically below line B, the greatest departure being $0\cdot07$ in y, at $x = 3\cdot2$.

(*c*) Line B represents a probable extension of the observations on water flowing through annular or very wide flat slits, up to $x = 4\cdot4$ or more.

Translating the foregoing into more convenient form we have:

For $h\,S/\nu < 1120$

$$\left.\begin{aligned}\frac{P}{l} &= \frac{12\,\mu\,S}{h^2}\\ &= 12\,\frac{\rho\,S^2}{h}\left(\frac{\nu}{h\,S}\right)\end{aligned}\right\} \quad . \quad . \quad . \quad (9)$$

Comments.—The observed resistances are generally a little higher than shown by equations (9), but not over 7 per cent. The equations may be used for any liquid or gas of which the viscosity and density are known.

For $1120 < h\,S/\nu < 25{,}000$

$$\left.\begin{aligned}\frac{P}{l} &= 0\cdot044\,\frac{\rho\,S^2}{h}\left(\frac{\nu}{h\,S}\right)^{0\cdot2}\\ &= 0\cdot044\,\frac{\rho^{0\cdot8}\,\mu^{0\cdot2}\,S^{1\cdot8}}{h^{1\cdot2}}\end{aligned}\right\} \quad . \quad . \quad (10)$$

Comments.—Becker's most accurate series (4 and 5) agree with equations (10) within ± 6 per cent. Series 2 and 3 give systematically lower values of P/l, the greatest departure being about 18 per cent., in the vicinity of $h\,S/\nu = 1{,}600$.

Equations (10) may be used for any liquid and will probably give values of P/l correct within 10 per cent. or 15 per cent., at least as far as $h\,S/\nu = 25{,}000$. At higher values of $h\,S/\nu$, the curve doubtless flattens out, as for round tubes, and values from equations (10) will be too low.

The observations on air are better represented by

$$\frac{P}{l} = 0\cdot0089\,\frac{\rho\,S^2}{h} \quad . \quad . \quad . \quad (11)$$

If the observations are to be trusted, this indicates that the flow of air was much more turbulent than that of water, as if the channels had become relatively rougher. Extrapolation by equation (11) to higher values of $h\,S/\nu$ than were reached in Becker's work, will give too high rather than too low values of P/l. There is no reason to suppose that other gases will not follow the same equation as air.

10. *Concluding Remarks.*—The numerical values of the quantities dealt with have all been expressed in C.G.S. units, but the coefficients of equations (6), (9), (10) and (11) would remain unchanged if any other normal system of units were adopted, *e.g.*, the foot-second pound-mass system. Whatever the units used, the equations retain the same form and remain applicable if the numerical coefficients are suitably modified.

The possible variations are too many to be discussed here, but two remarks may be made: First, that C.G.S. tables of density and viscosity are more likely to be available than others, so that it is well to keep ρ and μ in C.G.S. units; and second, that doubts regarding the values of the coefficients may always be avoided by reducing everything to C.G.S. units and working with the equations as given above.

If l represents the whole length of the channel, the value of P for any given rate of flow, computed from the equations here given, will be less than the overall pressure drop actually required, by the amount of the kinetic energy and entrance corrections. The kinetic energy correction, to be added to P is $P_k = k\,\rho\,S^2$, where $k = 27/35 = 0\cdot77$ for stream-line flow, and $k = 0\cdot5$ in the limiting case of extreme turbulence. In the absence of experiments similar to those of Stanton and Pannell* on round pipes, we cannot say how k varies between these limits, but $k = 0\cdot6$ will probably be a fair average value for speeds that are well above the critical region.

The values of l/h in Becker's and Fergusson's experiments were from 280 up, and the entrance resistances were negligible in comparison with the other sources of error. For short channels such as would result from cutting numerous labyrinth grooves in one of Becker's plugs, the entrance and acceleration resistances will absorb most of the pressure drop and the equations for long channels will not be applicable.

In addition to further work on annular slits, including cases where the surfaces are in relative motion, analogous experiments are to be desired on radial and spiral flow through disc-shaped clearances.*

* *Phil. Trans.*, A 214, page 199, 1914.

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

By W. NOBLE TWELVETREES, M.I.Mech.E., A.M.I.E.E., M.Soc.C.E.(France).

(*Continued from page* 196.)

IN considering the mechanical and electrical plant at the new generating station, the most logical course will be to follow the sequence of operations conducted, commencing with the reception and handling of coal, passing successively through the boiler and engine houses and allied departments, and finally dealing with the switch-house whence current is distributed to all parts of the city.

Coal Storage.—The area allotted for the bulk storage of coal is at the northern end of the property. Having a maximum length of about 955 ft. and a maximum width of some 435 ft., it extends from a point near the power-house to the River Tame, and is bounded on the two other sides by the existing filter beds of the sewage farm and by the Birmingham and Warwick Junction Canal, respectively. The area is clearly indicated in the plan of the station site given in Fig. 3, on Plate VI, which accompanied our issue of January 26.

The depot is served by sidings connected with the Midland Railway main line, and with a branch line of the London and North-Western Railway. After passing a weigh-house adjacent to the cooling pond site, the coal supply siding takes a curve and continues to the River Rea end of the storage depot. At a point 320 ft. from the end, a coal transporter, with an arm 270 ft. in length, has been erected commanding nearly one-half of the storage area, and providing for the transfer of coal between the depot and three lines of sidings near the canal bank. These sidings are in communication with the supply siding and also with three other sets of railway tracks: One, with two sets of rails, running along the new bank of the canal; another, comprising one set of rails, passing between the new canal basin and the coal pits; and the third, with two sets of rails connected both with the siding running from end to end of the coal depot and with the sidings near the canal, being between the coal pits and the power-house. One of the last-mentioned lines is continued across the switch-house canal arm on the lift bridge to which reference has already been made, and the other line affords communication with the engine-house loading dock by means of two turntables. The various sidings and tracks are equipped with cross-overs, points and all requisite appliances for the running of wagons in any required direction and their transfer from one line to another. These sidings and the coal pits are indicated in Fig. 3, but are shown somewhat more clearly in Fig. 28, which is a plan of the new canal basin to a larger scale. This figure appeared on page 194, of our issue of February 16.

Coal can be landed from barges alongside the new canal wall, and from barges in the new canal basin. There is ample space for the temporary storage of coal between the canal and the new basin, as well as in the pits in front of the power-house, coal being delivered to the pits by trains of wagons filled from the main storage depot. The area reserved for the latter will suffice for the storage of 80,000 tons eventually. Arrangements have been made for the reception and distribution of the incoming coal at the rate of 1,000 tons per week, and for delivery to the power-house at the rate of 100 tons per hour. Coal is supplied to the boilers by telphers capable of delivering 30 tons to 40 tons per hour to each line of three boilers, but under normal working conditions a supply of 20 tons per hour is adequate for each line. The plant for handling coal and ashes was supplied and erected by the Mitchell Conveyor and Transporter Company,

* Published by permission of the Director of the Bureau of Standards of the United States Department of Commerce.

Limited, in general accord with the original design prepared by Mr. Chattock, who fully realised the fact that the problem of coal and ash-handling called for bold treatment, and the selection of a type of plant providing for efficient command of the whole area covered by storage grounds, railway sidings and canal channels, and for the transport and delivery of coal into the overhead bunkers in the boiler-house. Reference has already been made to the admirable manner in which provision has been made for the storage and transport of coal, and we have now only to consider the plant installed for the mechanical handling of fuel, that for the disposal of ashes being deferred until the boiler plant has been described.

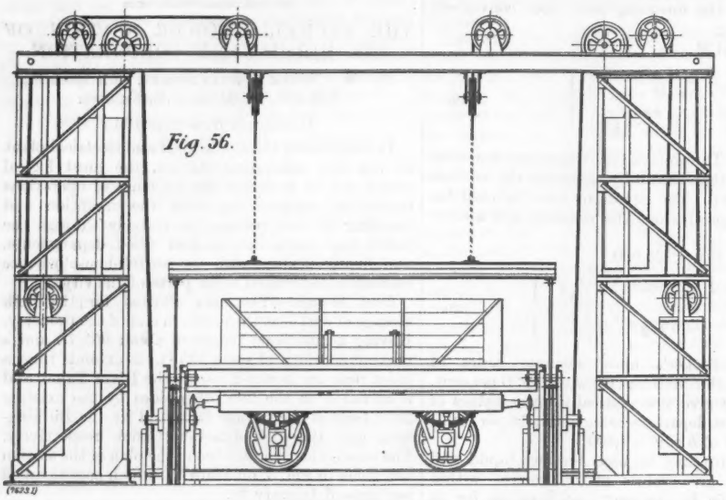


Fig. 56.

Coal-Handling Plant.—It was the original intention to fill the coal pits along the front of the power-house either by bottom discharge wagons or by hand-shovelling from side-door wagons, but the increased cost of labour suggested an improvement upon such methods. Therefore the Mitchell patent side discharge wagon tippler was adopted for the emptying of wagons conveying fuel along the railway lines connected with the main storage depot. The tippler, illustrated in Figs. 56 and 57, annexed, is almost entirely automatic, and its operation may be thus briefly described. After the wagon has been run upon the cradle of the tippler, the operator moves the lever of a tramway type controller to the forward notches. The machine then proceeds to support and clamp the wagon and to tilt it until the whole of its contents are emptied into the pit. This done, the operator moves the controller lever over to the reverse notches and the wagon is returned to its original position ready for removal from the cradle. During the process of tipping, the wagon is supported on its side by a beam running the whole length of the wagon, balance weights being provided to assist the motor in raising the dead weight of the wagon, coal and cradle. An electric motor of 8 b.h.p. is required to operate the machine, the power consumption being stated at 0·02 Board of Trade units per ton of coal handled. The capacity of the machine is 120 tons per hour.

For the conveyance of coal to the overhead bunkers in the boiler-house, either from the storage ground between the main canal and the new canal basin, or from barges in the canal basin, or from the coal pits in front of the power-house, the complete scheme provides for the installation of an imposing telpher plant comprising a series of eight elevated gantries with 16 tracks, supported by braced steel towers. At present, only three gantries with the requisite supporting towers, and six telpher tracks have been erected and equipped. The towers are built up from massive foundations of plain concrete, and rise to a height of 60 ft. above the new ground level. Figs. 59 and 60, on page 238, illustrate the general arrangement of the telpher towers and tracks, Fig. 59 being a view from the canal looking towards the power-house, and Fig. 60 a view from the power-house looking towards the canal and showing part of the new canal basin before the admission of water. Of the two other views, on page 238, Fig. 61 shows the mass concrete foundations for the main telpher supports, and Fig. 62 shows the construction of the closed-in culvert for the water course across the site of the coal store, which enabled the ground to be filled in to top level to form the store.

The two telpher tracks running overhead, 50 ft. above ground level, for a distance equal to the present length of the coal storage ground, are between 200 ft. and 300 ft. long and are connected by means of curves to six other tracks, arranged in pairs, at right angles to the longitudinal tracks. These transverse tracks project as cantilevers, 35 ft. 6 in., towards the canal for command of the coal storage ground, and in the opposite direction they extend to the power-house, entering the three portals shown in Fig. 59, and continuing over the length of the series of bunkers included in the steam boiler plant. Between the towers and the power-house wall the distance is 96 ft., and as the boiler-house is 98 ft. across, the tracks are 232 ft. 6 in. long from end to end. The total length traversed will be some 500 ft. when the generating station has been finally completed.

Each track consists of an underhung rolled steel joist with renewable wearing rails on the upper side of the bottom flanges. At each end of the curves, short lengths of the straight and curved tracks are mounted on a frame carried on rollers and forming two-way points, which are operated by small electric motors and driven through reduction gear by means of crank mechanism, the points being controlled from the telpher cabins. The electrical circuits are arranged on the block system; a length of track approaching each switch becomes dead as soon as the switch is opened, and mechanical stops are provided at the ends of the tracks to prevent over-running.

Five telpher cars have been supplied, each carrying a 1-ton grab. Each car is underhung from two 4-wheeled bogies, all eight wheels being driven by four small motors geared to the track wheels, which run on ball and roller bearings. The telpher frame carries the hoisting unit, from which are suspended the grab, a cabin for the driver and the requisite electrical apparatus. The hoisting unit has two drums, and is driven by a 15 b.h.p. motor. In the design of the driver's cabin care has been taken to make the controllers for hoisting and lowering, for operating the grab and for travelling the car, easily accessible. Moreover, the arrangement of the track switches is such that the driver can reach them, and drive along any portion of the track without having to leave the car. Thus additional labour for opening the track switches is avoided, and a considerable economy is effected. As a matter of fact the whole of the telpher plant can be worked even in the busiest times by five men, one in each car. Fig. 58, subjoined, shows the car complete with its grab, and it will be noticed that a bay window in the front gives the driver a good view, while a horizontal pane at the bottom of the bay window enables him to see the grab when it is operating at ground level.

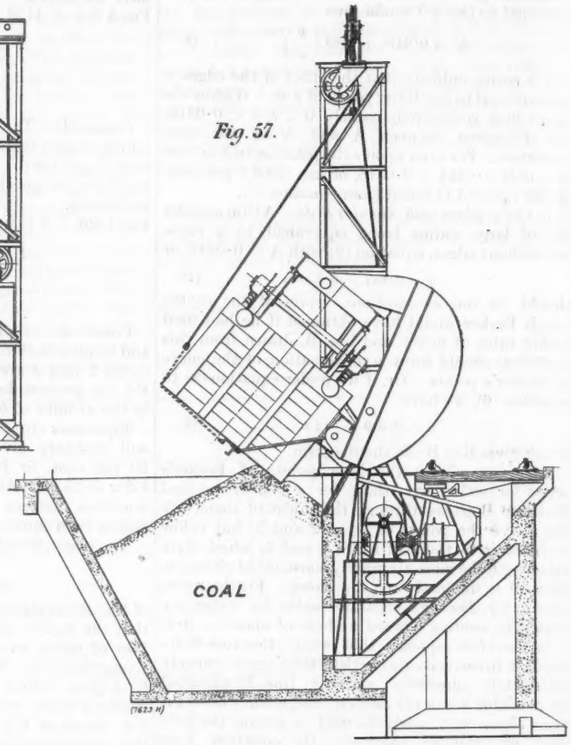


Fig. 57.

FIGS. 56 AND 57. WAGON TIPPLER.

FIG. 58. TELFER CAR FOR COAL-HANDLING PLANT.

The grab was specially designed to suit barges with a view to minimising hand trimming. Another feature is that the grab easily picks up its load

under any ordinary conditions, and need not be dropped upon the heap of coal with the idea of aiding the act of filling. Towards the end of the closing movement of the jaws, a toggle device comes into play, giving a very positive and secure action, which prevents the dropping of coal while the grab is being travelled. The power consumption for conveying coal from the storage ground to the bunkers, including a lift of 50 ft. and a travel of 300 ft., is 0·40 Board of Trade unit per ton of coal handled, the consumption for conveyance from barge to bunker being slightly less.

(To be continued.)

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE annual general meeting of the above Institution was held on Friday last, the 16th inst., at the Institution Building, Storey's Gate, Westminster, the chair being occupied, during the earlier part of the proceedings, by the retiring president, Dr. H. S. Hele-Shaw, who, later, vacated it in favour of Sir John Dewrance.

THE ANNUAL REPORT.

After the formal business, Dr. Hele-Shaw formally presented the annual report, and moved its adoption. The following is a summary :—

The seventy-sixth annual report showed a net increase on the roll of the Institution of 740, the total number of names amounting at the close of 1922 to 8,734. There were 1,238 additions during the year, including 177 members, 266 associate members and 260 graduates, while the new classes of companions and students were responsible respectively for 63 and 447 new names on the roll. The total deductions numbered 498, of which 75 were due to death, the bulk of the remainder being transferences to other classes. Among the losses by death were the names of Dr. E. Hopkinson, Sir George Carter and Professor Hubert. The first had been president of the Institution in 1919. The accounts showed a small balance against the revenue, which had been 28,655*l.*, while the expenditure had amounted to 28,737*l.* In connection with alloys research combined work on the alloys of iron had been instituted in conjunction with other societies, &c., and the Institution had made grants of 775*l.* in this connection. With sums from other bodies and from the Department of Scientific and Industrial Research, the fund at present amounted to 4,275*l.* The research would be carried out at the National Physical Laboratory. In connection with the Cutting Tools Research Committee, work had been carried out by Professor Coker, by Colonel Crompton, by Mr. Dempster Smith, by Dr. Stanton and Dr. Rosenhain, the two latter having commenced an investigation of the fundamentals of cutting action. The Hardness Tests Research Committee had continued its work and its second report would be presented shortly as a paper for discussion. The arrangements made for the proposed marine oil engine trials were progressing. So far seven firms building five representative and distinct types of engines had agreed to participate. The first report of the Steam Nozzles Research Committee had just been published in the Proceedings. The second report would be presented for discussion at an early meeting. The first report of the Research Committee on Wire Ropes was in course of preparation. The sum of 500*l.* contributed by Mr. R. Williamson towards piston ring research, had, with interest, been divided between work on cutting tools and wire ropes.

The Thomas Hawksley gold medal had been awarded to Professor Rateau for his paper on "The Use of Turbo Compressors for Attaining High Speeds in Aviation." In connection with the examinations, prizes of 5*l.* each had been awarded to Mr. R. P. Irwin and Mr. A. Crawford, and of 3*l.* each to Mr. S. W. Smith and Mr. H. S. Hanson. The alterations in the articles and by-laws were recorded in these columns as they were made. A new local branch had been formed for Glasgow and the West of Scotland, and sections for graduates and students had been formed in connection with two local branches. Advisory Committees for South Africa, Australia and New Zealand, had been established. In connection with the Engineering Joint Council a draft constitution had been agreed. The various meetings held during the session in London, and the summer meeting in Paris and Liége have been referred to in these columns. Seventy-two schools and colleges had now come in to the scheme for national certificates and diplomas; 1,253 candidates had been examined, resulting in the award of 519 ordinary and 68 higher certificates, and 96 ordinary and 32 higher diplomas.

Sir John Dewrance seconded the adoption of the report, and after some comments, and replies, by Sir John Dewrance and Dr. H. S. Hele-Shaw, to certain points raised, the report was carried.

PRESENTATION OF PRIZES.

Details of the prizes awarded, with the exception of those bestowed upon graduates, are given above. These prizes were presented by the President; a prize of 5*l.* was also awarded to Mr. E. T. Vincent, graduate, for his paper entitled "Some Types of Marine Oil Engines," and 5*l.* to Mr. F. Arnold Best, graduate, for his paper on "Airships."

ELECTION OF OFFICERS.

The ballot taken for members of the council had shown the following to be elected :—As president, Sir John Dewrance, K.B.E. Vice-presidents : Sir Robert A. Hadfield, Bart., and Mr. H. A. Ivatt. Members of council : Mr. Daniel Adamson, Mr. W. F. Cully (associate member), Professor W. E. Dalby, Mr. Charles Day, Mr. E. W. Moss (associate member), and Lieutenant-Colonel Pitt (associate member). The council had that afternoon appointed Sir Robert Hadfield as a Past Vice-president, Mr. William Reavell being appointed Vice-president, and, as a consequence, Mr. Maunsell had been appointed a member of council. To fill the vacancy caused by the resignation of Mr. Petter, Vice-Admiral Sir George Goodwin, K.C.B., had been appointed a member of council, and to fill the vacancy caused by the election of Mr. Ivatt as a vice-president, Mr. Richard Williamson had been appointed. The four gentlemen last-named would retire at the next annual general meeting. It was further stated that the following would serve as past-presidents on the council, namely, Sir John A. F. Aspinall, Dr. H. S. Hele-Shaw, Dr. W. H. Maw and Captain H. Riall Sankey; and as past vice-presidents, Mr. W. H. Allen, Sir R. A. Hadfield, Bart., and Mr. J. R. Hoyle.

INDUCTION OF NEW PRESIDENT.

Dr. H. S. Hele-Shaw then vacated the chair in favour of Sir John Dewrance, the new president, after which Captain Sankey proposed a vote of thanks to the retiring president. This was supported by Mr. Thompson and carried. Dr. Hele-Shaw, in acknowledgment, referred to the changed attitude of the Government towards the Institution. Membership was now accepted by the Government as a passport to employment in branches of mechanical engineering. The status of the Institution had during the past year for the first time been recognised not only in relation to national scholarships, but in the military services and other branches of the Government.

MECHANICAL PROBLEMS IN THE RUBBER INDUSTRY.

The paper down for reading and discussion was entitled "Some Mechanical Problems in the Rubber Industry," by Mr. H. C. Young, of Birmingham, associate member. We commence to reprint this paper on another page of this issue. It was summarised by the author, after which the discussion was opened by Mr. Daniel Adamson.

Mr. Daniel Adamson said he thought the paper, though comprehensive, was not quite complete enough for ordinary mechanical engineers to appreciate. As far as he understood the process, the crude rubber being first taken as it came from the plantations in dirty brown lumps and balls, was washed and passed through the mills, the colour being changed in the process to a rich cream tint. The work was chiefly done by the fluted rollers, and by the friction ratio, that was to say, the difference in speed between the front and the back rolls dragging the rubber between the rolls. After washing, heated rolls were used in order to change the granulated structure from the washing mills into a coalescent mass. Having got this condition, there were mixing rolls in which, again, the rubber was heated. Then various compounds and powders were added; and finally there was a warming mill which again heated the rubber prior to the more special processes such as calendering, or tube-making or strip-making for the tyres.

Power was a very important part of the question. A committee of the American Institute of Electrical Engineers, which included the Mr. Mottinger mentioned in the paper, had reported in 1921 on the question. They had found that all the mills ran up to approximately 1½ h.p. per inch width of the face of the roll, that varying with the temperature and quality of the material. The author suggested in the paper that about 1 h.p. per inch with the roll would be suitable. Could he explain this difference? The peak loads were very sharp and very frequent. It took about 1 second for the lumps of rubber to pass through. The American Committee found that if the number of machines on the same line was increased the peak loads did not coincide, so that, for example, six mills would only take the maximum power of 4½. The author referred to the fact that automatic mixers reduced the horse-power required by one-half. That was a very important economy in the cost of production.

With regard to the importance of safety stops, the milling of rubber seemed to be about the most dangerous process that engineers were acquainted with. The operators had to manipulate the rubber by hand, and owing to its nature, a man's hands were very apt to be drawn into the machine between the rollers. The tests of the American Committee showed that if one merely disconnected the motor electrically—simply cut off the switch at the end of the supply to the motor—the rolls would travel 75 in. That would be fatal to the unfortunate operator who was caught. If one disconnected the motor mechanically the travel was 16 in. Those figures were reduced to about 4 in. by the method mentioned by the author; the author had given 2 in. in his diagrams. The best way to ensure safety measures being reliable was to make use of them continually in service.

Mr. H. Savage said he believed that in this country most people had experienced difficulty with sulphur when utilising steam from vulcanisers. In all vulcanising operations there was some sulphur. Could the author explain how the sulphur in the waste steam could be got rid of? The author had referred to the use of steam from pass-out turbines for vulcanising in conjunction with the generation of power. The practice was successful in sugar factories, and similar places, where steam was required continuously, or more or less regularly, but in the vulcanising of rubber, the work was intermittent, except in very large factories. With regard to front and back rolls, he believed that one maker placed the back roll rather higher than the front one, perhaps because it was easier for the operator to work. That was a point which might be considered. The author assumed the use of alternating current for mill drives. That was rather sweeping, because in America rotary converters were put in to obtain continuous current for rubber manufacture. When calendering and extruding, it was desirable to have control of the speed, and this could only be got fairly satisfactorily with continuous-current motors. He did not observe any reference in the paper to motor driving. The chain drive for speed reduction was mentioned as an alternative to the gear drive. He considered that with certain forms of gear drive—the Citroën for example—better results were achieved than with the chain drive. Under "Solvent Recovers from Spreaders," the author had referred to the "Bensin condensation" system. He would, however, like to put in a word of caution as to the percentages of spirits said to be recovered. In the case of the apparatus named, the figure was given as 60 per cent., but it was difficult to ascertain the percentages exactly, because the basis taken was the amount of spirit in the rubber to make the dough in the first place, and some of this might be lost in the course of the various operations, &c., making the actual recovery higher.

Mr. J. H. C. Brooking said that previous papers on rubber manufacture had been read before the Chemical Society, and he felt, in spite of Mr. Young's remarks, that the chemical side of the subject was really the more important. It was difficult to appreciate the troubles, trials and difficulties incidental to the manufacture of rubber. He had been brought up as an electrical engineer, but since he had become connected with the rubber industry on the mechanical side, he regarded his previous difficulties as child's play. He would emphasise particularly the lack of information and standard knowledge in the rubber industry. Hundreds of materials were dealt with in rubber manufacture and also innumerable degrees of heat and time, which were of such vital importance that if only slightly exceeded, articles would be spoilt.

Mr. H. Rogers confirmed the previous speaker's remarks, and regarded Mr. Young's paper as an initial step towards securing information which could be publicly discussed and the problems involved thrashed out.

Mr. H. C. Young, in reply, on the question of 1½ h.p. per inch of roll, said it was not practicable to state

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

THE TANGENT TOOL ENGINEERING COMPANY, LIMITED, ENGINEERS, KEYNSHAM, SOMERSET.

Fig. 11.

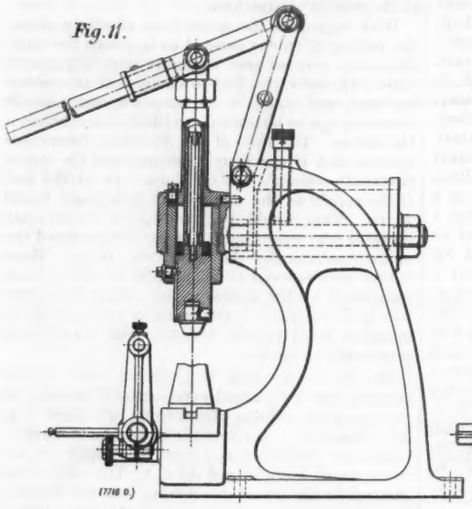
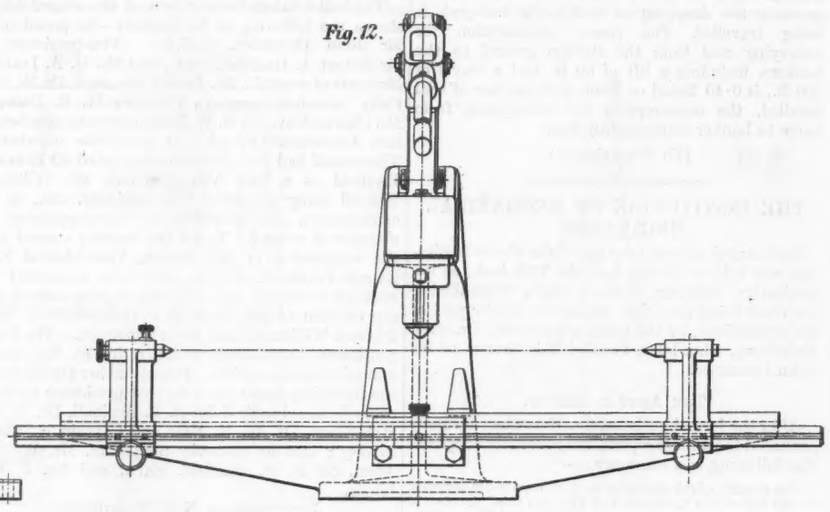


Fig. 12.



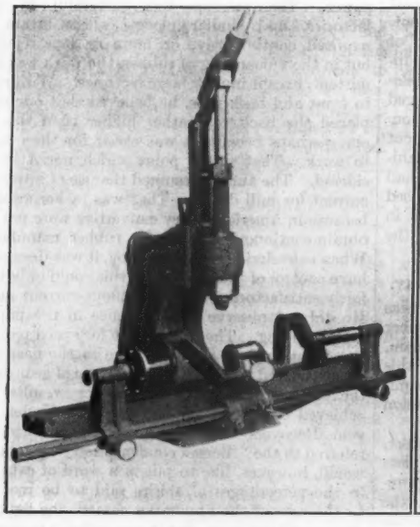


FIG. 13.

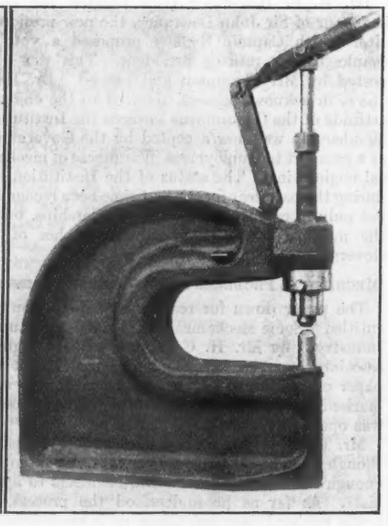
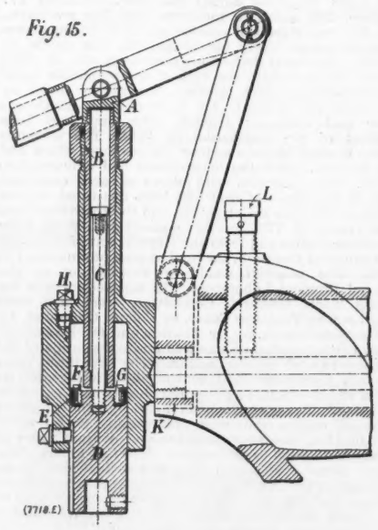


FIG. 14.

Fig. 15.



definitely the horse-power for a roll; any difference in soaking the rubber or in putting in the powders would affect the horse power. If American "best black" were used, or what in England was called "G.C. Black," the horse-power would vary. Thickness of blanketting, temperature of water going through the roll, the metal of the rolls, and numerous other factors all influenced the point. It was these matters that he would like to have scientifically arrayed, together with any phenomena attaching to them, and plotted out, so that they could be understood. In tube work and vulcanised articles with a high percentage of sulphur it was not possible to return the steam back into the mains; but in the case of ordinary pneumatic tyres, solid tyres and articles of that nature, there was not sufficient sulphur in the steam to trouble the maintenance engineer. In many factories the whole of the vulcanising steam, from these products, was turned into the heating mains with success. The figures he had quoted as to the saving effected in the case of several factories by this utilisation of waste steam were actual figures and spoke for themselves. On the question of the back roll being higher than the front, in Great Britain the front roll was usually 22 in. and the back roll 26 in., whereas in America the figures were reversed, though he did not know why. With the alternating-current commutator motor the speed could be controlled, and he had seen this type of machine operating with complete success. He had two alternating-current motors in use, one, of 60 h.p., on a calender, and another, of 120 h.p., on a 15-in. extruder, both of which did well. He believed the reason why the direct-current plant had been put into American factories was because the alternating-current motor had not come forward early enough. In America, he knew, they used synchronous motors on the back line, cutting out all gears. They employed a 1,000-h.p. motor direct on the back line, which was an enormous gain. Turning to efficiency of recovery, the actual efficiency could be ascertained by weighing at the spreading or at the soaking operations, thus finding out how much was finally recovered.

He hoped that his paper would generate a useful discussion if engineers were actually associated with the industry. He had written the paper with the honest hope that members would interest themselves in an industry which was one of the most important.

After a vote of thanks, the President announced the Annual Graduates Lecture which would be delivered on February 26, at 7 o'clock, by Professor Coker who would take as his subject "Some Photo-Elastic Researches in Mechanical Engineering Problems." An informal meeting would also be held on March 9 next. The proceedings then terminated.

THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM.

(*Continued from page* 206.)

IN our previous issue we dealt generally with the nature of the Birmingham Fair and illustrated and described certain of the exhibits. Now that the Fair has been open for several days it is possible to refer in more detail to the scope of the exhibition and to give the general impression created by the display as a whole. In point of magnitude, the Fair this year is not appreciably different from last year, although an exact comparison of the number of stands shows that a slight falling-off has occurred, the total number having diminished from 502 to 480. Several firms are this year showing for the first time, and on the other hand one misses some of those who have been represented on previous occasions, but on the whole the variety and standard of the exhibits is well maintained. As regards the machinery section, which occupies one of the two main buildings in which the exhibits are displayed, we must again

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

MESSRS. HOLT AND WILLETTS, CRADLEY HEATH, STAFFORD.

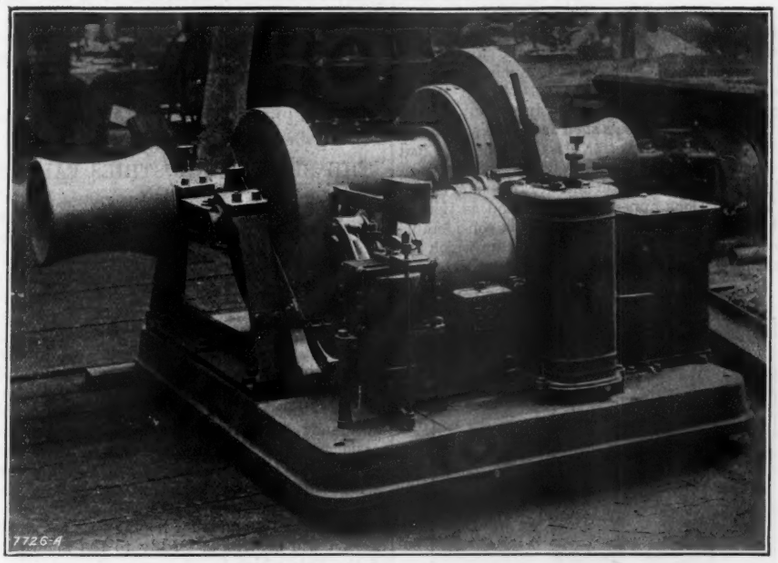


FIG. 16. ELECTRICALLY-DRIVEN WINCH.

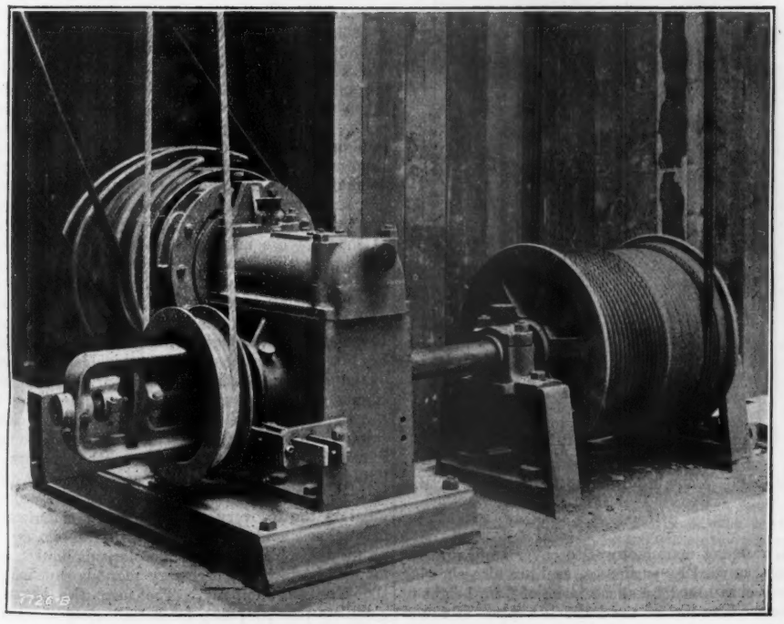


FIG. 17. BELT-DRIVEN HOISTING GEAR.

express regret at the abstention of so many firms of first-class reputation as builders of engines, turbines, machine tools, &c., from participating in this exhibition. Their absence gives a serious want of balance to the fair as a representation of the British engineering industry, and a foreign merchant might almost go away convinced that articles such as those we have mentioned and many others could hardly be obtained from British manufacturers.

In cases where the display of full-sized plant is impracticable, a stand furnished with photographs and literature, and with a competent engineer in charge, would do something to meet the requirements of the situation. Moreover, no restrictions ought to be placed by trade associations upon their members participating in a national enterprise of this kind, for the policy of exclusiveness is prejudicial to the extension of British trade abroad, and largely negatives the objects of the Fair. There is no exhibition in Great Britain, whether organised by trade associations or otherwise, in which anything like so much care is taken to encourage the presence of foreign buyers and to facilitate their purchases, as is the case at these fairs and it is a very shortsighted policy on the part of our manufacturers to neglect the introduction to foreign markets which is thus made available to them. Trade may be bad, and consequently there may be very little money to spare for exhibition, but when a firm is considering whether it can afford to spend money on exhibiting it should consider equally seriously whether it can afford to be entirely unrepresented at a fair of this character.

Returning now to the consideration of the exhibits themselves, we illustrate on the opposite page further articles shown by the Tangent Tool Engineering Company, Limited, of Keynsham, Somerset, in addition to those which we described last week. Figs. 11 to 13 show a hand-operated hydraulic straightening press for motor crankshafts and similar work. Fig. 14 shows the application of the same principle to a punching machine, while in Fig. 15 the hydraulic intensifying apparatus common to both types of machine is shown in section. The straightening press has a stroke of 2 in. and exerts a pressure of about 3 tons with an ordinary pull on the hand-lever. The shaft is straightened between bending blocks adjustable along the bed, and its condition at any time can be determined by rotating it between the centres provided, and noting the deflection of a micrometer indicator placed in contact with any of the journals. The illustrations render this sufficiently clear. The punching machine, shown in Fig. 14, will exert a 5-ton pressure on the tool with an ordinary pull. This is quite sufficient for closing $\frac{3}{8}$-in. rivets, hot, for which the machine was first designed, the rivet well filling the hole. The stroke is 1·25 in., and as the rivet is closed with a single pull of the handle, the operation is very rapid, which is a great consideration with small rivets, which cool quickly.

The action of the hydraulic mechanism will be understood from Fig. 15, which shows a section through the arrangement as fitted to the straightening press. The hydraulic unit is of steel throughout. Attached to the operating lever is a cross-head A, to which is screwed a hollow plunger B, the joint being made by means of a copper washer. Inside this plunger is a rod C which is screwed into the ram D. The bore of the plunger is less at its lower end, so that on the upward stroke of the lever, the internal shoulder in the plunger catches the head of a screw fixed in the upper end of C and effects a positive withdrawal of the ram, ready for the next stroke. The cup leather E is fixed to the ram by the screwed clamp washer F, the spring ring G being fitted inside the leather to keep it against the walls of the cylinder. This prevents any leakage past the leather while the ram is being withdrawn or when the tool is standing idle. The cylinder is filled with petroleum jelly or thick grease, by means of the filling plug H. Rotation of the ram is prevented by a set-screw engaging with a keyway as shown. The rocking link which acts as a fulcrum for the hand-lever is not attached, in this design, directly to the machine frame, but to a block K which is forced over a cylindrical nipple projecting from the cylinder. The cylinder is fastened to the frame by means of a screwed stud as shown, the block K lying in a groove slotted in the casting. This arrangement provides for a vertical adjustment of the whole hydraulic unit, to increase or diminish the "daylight" of the press. The screw L prevents the vertical adjustment being shifted by the working pressure of the tool when under load. It will be noted that there is an entire absence of valves in the design, and that the full downward travel of the ram is obtained by one movement of the lever. The full pressure can be exerted during the whole stroke of the ram, and the latter is positively returned for its next stroke. In the unit illustrated the area of the ram is 3·5 times that of the plunger, so that the pressure due to the leverage of the handle is multiplied hydraulically in this proportion.

Messrs. Holt and Willetts, of Cradley Heath, show a large collection of lifting appliances of various kinds, operated by hand, belt, or electric power. The machine illustrated in Fig. 16 is an electrically-driven winch for cargo or shipyard use. A totally enclosed reversible electric motor, developing 15 b.h.p. at 700 r.p.m., drives the drum through double-reduction machine-cut spur gear. The drum is of cast-iron, machined all over, and at one end of it is a large brake-wheel fitted with a pedal-operated band brake, for lowering. During this operation the pinion on the second motion shaft is held out of gear by a latch-lever working in a notched quadrant. The shaft of the motor is also fitted with a brake-wheel and brake, the latter normally being held in the "off" position by a solenoid excited by the motor current. Should the current fail or be interrupted, this brake at once comes into action and holds

the motor-shaft and therefore the load. The winch is capable of exerting a pull of 3 tons direct from the drum, at a speed of 56 ft. per minute. Electric winches of the same general design are made by Messrs. Holt and Willetts in all sizes from 10 cwt. to 10 tons capacity. The other exhibit of this firm which we illustrate is the belt-driven hoisting gear shown in Fig. 17. This is made for either goods or passenger work. It will lift a load of 1 ton at from 60 ft. to 70 ft. per minute. The main lines of the machine are extremely simple, comprising little more than a hoisting drum driven by an open and crossed-belt arrangement through a totally-enclosed worm gear. The machine is, of course, started, stopped, and reversed by shifting the belts, the striking gear being operated by a hand rope passing round the flanged cast-iron wheel shown mounted on an extension of the drum shaft. This wheel also carries a cam-plate which releases a brake on the wormshaft at the same time that either belt is brought on to the fast pulley. Normally this brake is held on by a weighted lever. The operator cannot reverse the lift when stopping, while over-winding is prevented by an adjustable automatic device which actuates the belt-striking gear as soon as ever the drum has made a predetermined number of revolutions. This is entirely mechanical, and in no way dependent upon the action of the operator or upon the condition of the starting rope. The drum shaft terminates in a screwed portion, and a nut on the screw is prevented from rotation with the shaft by having to slide in a casting which is attached to the rope wheel. Adjustable stops limit the travel of the nut, and when it comes up against either stop it causes the rotation of its guide casting and so turns the rope wheel and shifts the belt.

Messrs. J. B. Stone and Co., Limited, of 135, Finsbury-pavement, London, E.C.2, show a range of Wilson's patent nibbling machines for rapidly cutting sheet metals into any form, no matter how complex. These machines are really small fast-running punching machines, and were originally designed during the war to obviate the necessity for press blanking tools for certain classes of work. The general appearance of one of these tools is illustrated in Fig. 18, on this page. The shaft is put into motion by a friction clutch operated by the small handle shown. The front end of the shaft terminates in an eccentric pin carrying a brass block which fits into a cross-slot in the reciprocating head. The rotation of the shaft obviously causes the head to move up and down in its guides. A small punch at its lower end works in conjunction with a female die carried on the bedplate. The work is fed across the path of the punch by hand, the feed being governed by a small pin on the face of the punch. A small crescent of metal is thus removed at every stroke of the punch. The arrangement permits the cut to be made in any direction, so that complicated curves can be traced as easily as straight lines. The speed of cutting is remarkable and the metal is quite undistorted by the cut. It is quite easy to cut dished metal on these nibbling machines, and the use of templates enables work to be done that would be practically impossible on machines of any other kind. Samples of work up to $\frac{5}{16}$ in. thick are shown on the stand. The machines are built in various sizes with standard gaps ranging from 6 in. to 12 in., or with special gaps for particular kinds of work. Judging by the demonstrations given at Messrs. Stone's stand, and by the samples exhibited, these machines should be really valuable in any sheet metal working shop.

The Brooke Tool Manufacturing Company, of Warwick-road, Greet, Birmingham, have a very good collection of small tools such as twist drills, reamers, milling cutters of all kinds, hobs, involute gear cutters, &c., on view. Their particular novelty this year is an expanding spiral reamer, made in sizes from ½ in. to 2 in. Expanding reamers with straight teeth are not uncommon, but we believe that until now the principle has not been applied to reamers with spiral teeth. The teeth do not reach to the end of the reamer which terminates in a short plain part. This and the fluted portion are bored out, so that the reamer is hollow, and the flutes are slit so that all the teeth are separate, except at their ends. A screw tapped into the end of the bore, bears at its point against the internal surfaces of the teeth, and by screwing it in the exact cutting size of the reamer is adjusted. The Brooke Tool Company show many interesting types of cutters for metal and other material, one being a ground, toothless disc used for cutting up caramels into their well-known square shape. These discs are mounted 72 at a time on an arbor with distance pieces between them, the whole working as a gang cutter.

Messrs. C. A. V. Small Tools, Limited, of 181, Queen Victoria-street, London, E.C.4, are to be congratulated on having seriously taken up the manufacture of small tools such as callipers, squares, dividers, &c., for the better class of which we had previously been almost entirely dependent upon foreign sources. The finish and workmanship of this firm's productions appear quite as good as that of the best imported tools. They show a considerable variety of types and sizes at Birmingham which are worth inspection. They have recently extended

Fig. 18. Nibbling Machine; Messrs. J. B. Stone and Co., London.

their range of manufactures to cover hand pruning shears, as used by gardeners, and are also showing a very cheap model-maker's lathe of 2 in. height of centres. The bed of the lathe is a piece of round shafting, and the price of the whole machine, with two headstocks and tool-rest, is only 2*l.* 10*s.*

Messrs. Hollings and Guest, Limited, of Thimble Mill-lane, Birmingham, are showing applications of the hydraulic press to various purposes, most of which we have dealt with on previous occasions. On their stand is to be seen a hydraulic tyre press for pressing on or off the solid rubber tyres of commercial motor vehicles. These tyres, of course, are fastened to a steel rim, which has to be pressed on to the steel casting which forms the wheel. The press in question will exert a pressure of 200 tons, and is supplied with either hand or power-driven pumps. The framework is of the steel girder type, and carries a runway which picks up the wheels and carries them right into the press. Another machine shown is a bending press for bending plates cold up to 6 ft. in width. The press has a swinging column at one end, so that when a plate is bent into a closed form, the column can be swung out of the way, and the finished work taken out by being slipped over the presshead. Presses of this type are built by Messrs. Hollings and Guest, Limited, to deal with plates up to 20 ft. wide. A scrap metal bundling press for pressing old tin cans, &c., into solid blocks, weighing about 1½ cwt., and measuring 27 in. by 15 in. by 6 in. deep, and a baling press for dealing with waste paper, straw, rags, leather, &c., represent further specialities of the firm.

(To be continued.)

THE BRITISH INDUSTRIES FAIR IN LONDON.

The London Section of the British Industries Fair, which is running concurrently with that at Birmingham, was opened on Monday last at the White City, Shepherd's Bush, and will remain open until Friday, March 2. Elsewhere in this issue we deal fully with the exhibits at the Birmingham Section of the Fair, as the majority of these are of direct professional interest to the engineer. The exhibits at the London Section, on the other hand, consist mainly of the finished products of industry such as pottery and glassware, leather and fancy goods, musical instruments, furniture, stationery, jewellery and cutlery, electro-plated goods, sports goods, drugs and chemicals, &c. A most attractive and impressive display of these goods has been made at the White City, so that there are good grounds for hoping that the London Section will contribute largely to the main object of the Fair which is, of course, the extension of British overseas trade.

Most of the comparatively few exhibits of technical interest, with which we now propose to deal briefly, are collected in the chemical section, and among these is the colloid mill shown by Plauson's Mill and Filter Press, Limited, Seymour House, Waterloo Place, S.W.1. The mill consists of a steam-jacketted cast-iron casing in which beaters revolve at a high speed between fixed radial baffle plates, and by its aid colloidal dispersions of many solid and liquid materials in liquids can be effected. Dispersions of substances such as colours, ores, sulphur, China clay, &c., are required in numerous industrial processes, but a particularly interesting application of the colloid mill is in the manufacture of soap by the mechanical admixture of fat and alkali; by this means the necessity for the usual boiling process is avoided. The mill is made by Messrs. Mather and Platt, Limited, of Manchester. Another interesting exhibit is that of the Kestner Evaporator and Engineering Company, Limited, 5, Grosvenor Gardens, S.W.1, which includes some of the many applications of silica gel. This material is made in the powdered or crystalline forms by a patented process from water-glass and either sulphuric or hydrochloric acid, and it may be used industrially for adsorption from the gaseous or liquid phases, as a catalyst, or as a carrier for catalytic materials. Of its possible applications we may mention the recovery of solvents, the manufacture of sulphuric acid, refining of petrol and oils, drying air for use in blast furnaces, decolorising liquids, &c., for all of which the necessary plant is supplied by the Kestner Company. The firm also shows a glandless plunger pump for handling acids, a small hand pump in which the pumping action is obtained by rollers running over a rubber tube, a laboratory-type horizontal evaporator and an acid elevator.

Autoclaves and stills are shown by Messrs. Brown and Son, of Holloway, N.19, and by Messrs. W. J. Fraser and Co., Limited, of Dagenham, Essex, the exhibit of the latter firm including one of their standard periodic stills. With this still, eight different arrangements of the component parts are possible to suit various industrial processes. Messrs. Fraser also show examples of acid-resisting valves for use in chemical works, the valve bodies being made of regulus metal for pressures up to 60 lb. per square inch, and of cast steel lined with regulus metal for higher pressures. Acid-resisting vessels of enamelled cast iron are shown by Messrs. T. and C. Clark and Co., Limited, of Wolverhampton, and by the Cannon Iron Foundries, Limited, of Deepfields, Staffordshire, while at the stand of the Aluminium Plant and Vessel Company, Limited, of Wandsworth,

some examples of aluminium vessels for chemical operations, brewing, varnish making and the preparation of foodstuffs are displayed. Another interesting exhibit in this section is that of the Roberts' Patent Filling Machine Company, 33, Deane Road, Bolton, who show a variety of machines for filling bottles, tins, cans, drums, or casks with any kind of liquid, but especially suitable for dealing with liquid metal polishes, paints, varnishes. oils, syrups and other thick or viscous fluids. In most of these machines, the vessel to be filled is placed on the pan of some form of weighing machine under a valve connected by a pipe to a supply tank. When the vessel is filled with the predetermined weight of fluid, the scale pan drops and makes an electrical contact which closes the valve and thus cuts off the supply of fluid.

The optical exhibits are by no means numerous, but one of the more noteworthy items is a small surfacing machine for grinding and polishing single toric, spherical and cylindrical lenses used by oculists. This machine, which is made by Messrs. Somco, Limited, 35, Charles Street, Hatton Garden, E.C.1, works on the principle of the harmonograph. The lens to be ground is mounted on a "button" which is worked over a fixed cast-iron tool, charged with abrasive material or rouge, by means of a vertical rod attached to a horizontal lever. The latter receives its motion from two eccentric pins driven by spur and bevel gearing, the combination of the eccentric motions being such that over 5,000 cycles are completed before the lens repeats its motion in any particular path. We understand that one surface of a lens can be finished in about 30 minutes on this machine, and that one man can easily superintend the working of six machines. A somewhat similar machine, in which two lenses can be finished simultaneously, is shown at the stand of the Imperial Optical Company, 101 and 102, Hatton Garden, E.C.1, and this firm also exhibits a machine for grinding the bevels on the edges of spectacle lenses, a diamond cutter for shaping lenses, and a diamond drill for drilling the holes in toric and other spectacle lenses to enable them to be mounted in frames. Messrs. C. W. Dixey & Son, 3, New Bond Street, W., show a new form of bevelling machine for spectacle lenses in which the lens is clamped by a pair of rubber washers and held between two grinding wheels. The planes of rotation of the two wheels are parallel, but out of line, and the lens is held so that its plane makes an angle of about 45 deg. with the planes of the wheels. The latter can thus be made to act on both edges of the lens simultaneously, so that the bevelling operation can be completed in one revolution of the lens. The final shape of the lens is determined by a former which varies the distance between the adjacent edges of the two grinding wheels; the pressure of the latter on the work is regulated pneumatically. The machine can bevel from 12 to 15 lenses per hour to any desired shape.

Of the miscellaneous exhibits we may mention the X-ray tubes, rectifier tubes, high-frequency apparatus and wireless receiving sets shown by Mr. G. C. Aimer, 30 and 32, Mortimer Market, Tottenham Court Road, W.1, and the rustless-steel drawing instruments by Messrs. Norton and Gregory, Limited, of Castle Lane, Westminster, S.W. A new feature in the exhibit of the last-mentioned firm is a ball-bearing joint for compasses, dividers, &c., the object of this particular form of joint being to give easy movement in conjunction with reduced wear. Dewar flasks for liquid air are shown by the National Glass Industry, of Tottenham, N.15, and some of the examples, we noticed, had a coating of copper deposited on the glass near the mouthpiece for protection purposes. A material made by vulcanising rape-seed oil and used for diluting, and thus cheapening, rubber, is shown by Messrs. Typke and King, Limited, of Mitcham Common, Surrey, who also exhibit colouring materials for rubber manufacture, as well as some examples of rubber in which these materials had been employed. Kinematograph apparatus is shown by several firms, but the exhibits, in general, contain few points of novelty. We noticed however, a new form of arc lamp for projection work at the stand of Messrs. E. F. Moy, Limited, Greenland Place, Camden Town N.W.1. In this lamp, which is of the hand-fed type, the carbons are placed horizontally and arranged so that the rear, or negative, carbon passes through a hole in the centre of a concave metal mirror measuring about 5 in. in diameter. The mirror is made of an untarnishable and heat-resisting alloy and its use, we were informed, effects a very material saving in current consumption for a given degree of illumination and also renders the use of a condenser unnecessary.

Finally, a brief reference should be made to the exhibit of brush-making machinery shown in motion at the stand of Messrs. E. Berry and Son, Clyde Works, Birmingham, in the section devoted to brushware. Several types of independent drilling and filling machines are shown, but the most interesting of them is a new machine in which the operations of drilling and filling are carried on simultaneously. This machine is made in three models for dealing with brushes of various sizes, and in all cases its action is fully automatic. Blind holes are drilled in the back of the brush, tufts of bristle are selected from a bundle, doubled, fastened with wire clips at the bend, and inserted in the holes; the wire clip, it should be explained, is opened out by the pressure on the bottom of the hole so that its two ends penetrate into the sides and prevent the bristles from being withdrawn. The mechanism by which the various operations are carried out is interesting, and ingenious, but the space at our disposal prevents us from describing it in detail here.

INDUSTRIAL NOTES.

THE Ministry of Labour state that employment during January showed little general change as compared with previous months, but was better on the whole, at the end of the month than at the end of December. It continued good in the coal-mining industry, in steel sheet manufacture and in the worsted industry, fairly good in the tin-plate trade, and fair in the paper and other trades. In many of the principal industries it was still very slack; but a further improvement was reported at iron and steel works, and slight improvements were also reported in some centres in the engineering and shipbuilding industries, and in certain other sections of the metal trades. The percentage unemployed among members of trade unions from which returns are received, was 13·7 at the end of January, as compared with 14·0 at the end of December and 16·8 at the end of January, 1922. The percentage unemployed among workpeople insured under the Unemployment Insurance Acts in Great Britain and Northern Ireland was 12·7 on January 22, as compared with 12·2 on December 18, and 16·0 at the end of January, 1922. The total number of workpeople registered at the Employment Exchanges as unemployed on January 29 in Great Britain and Northern Ireland was approximately 1,460,000, of whom 1,138,000 were men and 226,000 were women, the remainder being boys and girls. On January 1 the corresponding total was 1,542,000, of whom 1,199,000 were men and 255,000 were women.

In the industries for which statistics are compiled by the Labour Department, the changes in rates of wages reported as having taken effect in January resulted in an aggregate reduction of nearly 56,000*l.* in the weekly full-time wages of about 500,000 workpeople, and in an increase of 42,000*l.* in the wages of 650,000 workpeople. The net weekly reduction of 14,000*l.* is less than that recorded for any previous month since the beginning of 1921. The principal groups of workpeople affected were coal miners and men employed in the shipbuilding industry. In the coal-mining industry there was a slight reduction in wages (equivalent to less than 0·05 per cent., on current rates) in Northumberland, but there were increases equivalent to about 2 per cent. on current rates in the Yorkshire and East Midland area, 2½ per cent. in Durham, and nearly 7 per cent. in Scotland. In the shipbuilding industry all classes of men except the lowest paid time workers sustained reductions varying, according to earnings, from 2*d.* to 2*s.* 6*d.* per week. Among other large bodies of workpeople whose rates of wages were reduced in January were men employed by electrical contractors, house painters in Scotland, iron and steel workers in South Wales and Monmouthshire, lead smelters, bobbin makers, road transport workers in Lancashire and Yorkshire, soap and candle workers, brewery workers at Burton, and men employed by waterworks undertakings in various districts. As a result of orders made under the Trade Boards Acts there were also reductions in the minimum rates of wages fixed for workpeople in the stamped or pressed metal ware, and wrought hollow-ware trades. Apart from coal miners, the principal groups of workpeople whose wages were increased in January were ironstone miners in Cleveland, blast-furnace workers in Cleveland, Cumberland, Northamptonshire and the West of Scotland, workpeople in the making-up and packing trade at Manchester, woollen and worsted workers at Leicester.

On February 1 the average level of retail prices of all the commodities taken into account in the statistics prepared by the Ministry of Labour (including food, rent, clothing, fuel, light and miscellaneous items) was approximately 77 per cent. above that of July, 1914. The corresponding figure for January 1 was 78 per cent., and that for February 1, 1922, 88 per cent. The highest point reached was 176 per cent. above the pre-war level, in November, 1920, and the present figure is the lowest recorded since October, 1917. For food alone the increase on February 1, as compared with July, 1914, was 73 per cent.

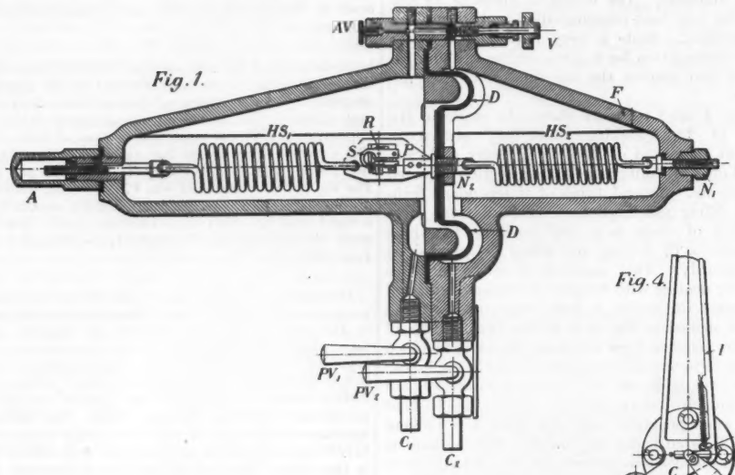
The number of trade disputes involving stoppages of work, reported to the Labour Department as beginning in January, was 54. In addition, 17 disputes which began before January were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in January was approximately 19,000, as compared with 7,400 in the previous month and 15,400 in January, 1922. The estimated aggregate duration of all disputes during January was 117,000 working days, as compared with 72,000 days in December, 1922, and 162,000 days in January, 1922.

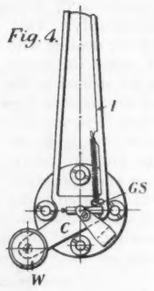
In the ninety-third quarterly report issued by the General Federation of Trade Unions, it is stated that complaints of the inaccuracy of the Board of Trade figures have reached the Management Committee from time to time. The last came from the members of the Portsmouth branch. The Management Committee replied to this that they fully sympathised with the position of the branch and with their desire to correct any errors in the Board of Trade figures concerning the cost of living. The Board of Trade figures were, however, taken from over 1,000 sources, and it would be impossible for the Federation to touch anything like such a number. To take one or two here and there would be very dangerous, and any conclusion reached as a consequence of isolated inquiries might easily be upset by the statisticians attached to the Board of Trade. The Management Committee were of opinion that the branch would realise how easily the Federation might be attacked if they attempted to reach any general conclusion concerning these figures from the very imperfect opportunities they would have to make the inquiries, and stated that the branch, perhaps, would remember that another organisation did make an inquiry on inadequate lines, and that their report was torn to shreds in the Journal of the Royal Statistical Society.

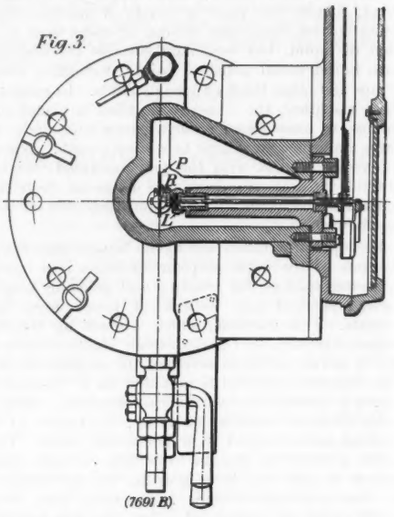
The Supreme Court of Massachusetts, says *The Iron Age*, New York, has finally established for the State, and as a precedent to guide litigation in other States, the principle that an employer has a right to discharge his men if they will not sign individual contracts to give up membership in a union, and that if such discharged employees combine to picket his plant or interfere with his place of business for the purpose of compelling him to take them back under the old employment relations, he is entitled to restrain such interference by injunction. The case was that of the Moore Drop-Forging Company, Springfield, *versus* the Springfield Central Labour Union. The company, all of whose employees were union members, requested them to sign contracts providing that whilst employed they would not be or become members of any trade union. Those who refused to sign were discharged, others struck in protest, and all combined to carry on various activities against the company to compel it to abandon the contracts of employment. After the company had filled the places of the striking and discharged men, and had resumed work, the Union took up the conflict, and it was against interference from this source that the action was brought in the Supreme Court. The decision of the latter is as follows: "The plaintiff was entitled to make it a condition that those entering his employment should not be or become members of a labour union, and is entitled to be protected by the law, and to receive whatever benefits may accrue from such a contract. The right of one to have the benefit of his contract is a right which can lawfully be interfered with only by one who is acting in the exercise of an equal or superior right which comes in conflict with the other. The members of the Central Labour Union had no right to interfere with the plaintiff's business for the illegal purpose of forcing him to abandon the making of individual contracts with his employees." Under this finding, says our contemporary, a shop may be made out-and-out non-union, and the outsider

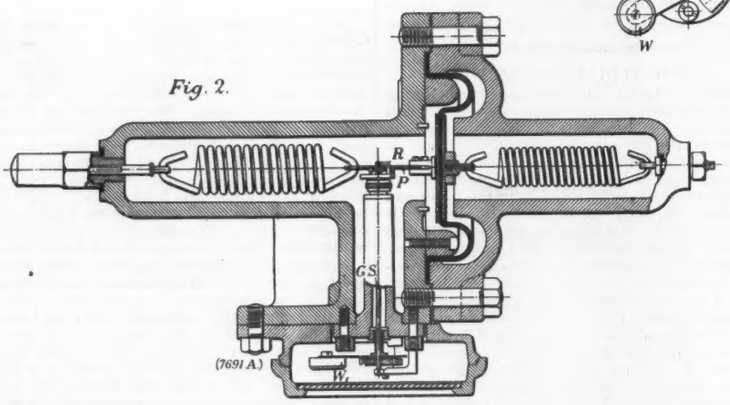
BOILER LOAD-INDICATOR.

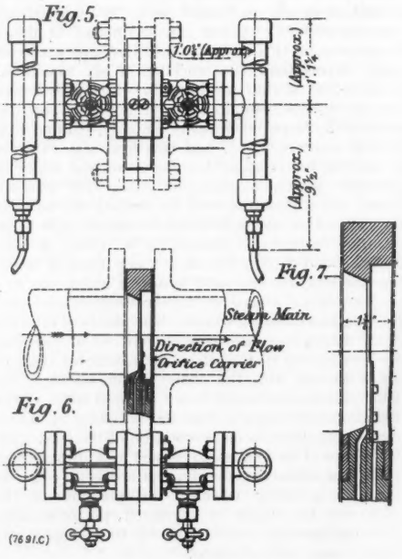
CONSTRUCTED BY MESSRS. GEORGE KENT, LIMITED, ENGINEERS, LUTON.











has no right to interfere; in other words, the employer is given equal privilege with the employee.

Speaking last week at Sunderland, Mr. Philip J. Ryan, Director of the Northern Federation of the National Alliance of Employers and Employed, said that repair work in British shipyards at present was seriously hampered by trade union limitation of the number of men to be employed on one job and the amount of overtime which might be worked. When repairs to the steamer Rowden in dry dock were almost finished, the men engaged upon the vessel refused to hammer up 18 rivets because this would have involved a larger allowance of overtime than permitted by the unions. Hence, the owners were involved in considerable expense in dues and demurrage, resulting from the cargo remaining in the dock for another 24 hours. A position like this was serious, for the repairers, anxious to finish the job, could neither employ additional men nor induce those already employed to work overtime. When one learned that on urgent jobs of this kind, Dutch firms sometimes employed as many as three squads of riveters on one plate—a proceeding which would not be permitted in Great Britain—it was not to be wondered at that ship-repairing work which should be done in this country was going abroad. The ordinary trade unionist in this country simply wanted good work and steady wages, and had no objection to working overtime occasionally, particularly if he were paid time and a half. For this reason, special efforts should be made by both sides of industry to find some means of co-operation to keep work here, thus reducing unemployment.

The question of overtime on exceptional and urgent work, and on night shifts in shipyards, referred to in our last issue, is to be balloted upon by the shipbuilding unions. The terms of the ballot are to be drawn up this week by the committee of the Federation of Engineering and Shipbuilding Trades. It is announced that the ballot is to be returnable on March 21. In the interval further ships will probably go abroad for completion or repairs.

THE KENT BOILER LOAD INDICATOR.

THE boiler load indicator of Messrs. George Kent, Limited, of High Holborn and Luton, which we illustrate in figures 1 to 6 on this page, represents a new type of steam meter, especially designed by Mr. John Hodgson, of the firm, for boiler-house service. We mentioned the novelty in our articles on the Physical and Optical Societies' Exhibition, on page 36 *ante*, reserving the detailed description. Our diagrams, Figs. 1 to 3, are horizontal and vertical sections through the instrument which is a cylindrical casting, about 20 in. long, mounted in front of the boiler. The dial, which marks the pounds of steam consumed is not shown, except in section in Fig. 3. Details of the characteristic crank mounting are illustrated in Fig. 4. This part of the mechanism is visible in the actual instrument through the glass cover of its cylindrical casing; above the casing opens out into the dial sector. The orifice fitted into the steam main, with its cooling chambers and the carrier, is shown in Figs. 5 and 6. In the metropolitan district the first of these meters was installed last autumn in the power station of the Brompton and Kensington Electricity Works, which are adjacent to the West Brompton station of the District Railway.

Copper pipes connect the cooling chambers of the orifice, Fig. 5, with the tubes C_1 and C_2 of the meter (Fig. 1). The difference of pressure across the orifice acts on the two sides of the stout rubber diaphragm D, the peculiar shape of which can be seen in Figs. 1 and 2. The diaphragm is held between two helical tension springs $H S_1$ and $H S_2$ and any change of pressure on the two sides will cause the diaphragm to move. In the instrument and diagrams the steam flow is from left to right, the pressure on the up-stream side of the orifice acting on the left hand side of the diaphragm. An increase of pressure will thus cause the slotted plate P which is fixed to the diaphragm to move from left to right. The actual range of the motion is very small; it amounts to 0·3 in. only for the change of pressure corresponding to the maximum flow. It will be understood that the actuating fluid is not steam, but condensed water; the cooling chambers are added for this purpose to the orifice, and the pipes and the instrument itself are filled with condensed steam. A vertical flat on the plate P pushes up against the roller R seen in Figs. 1, 2 and 3; the roller is attached to a specially-shaped crank S (Fig. 1) on the gland spindle G S to which the pointer I is attached. A weight W on a cranked extension of I, Fig. 4, keeps the roller R pressed up against the flat on the plate; in this way the movement of the diaphragm is transmitted through S to the gland spindle (Figs. 2 and 3). The way in which the plate P is held between the springs H S can be seen in Fig. 1; the roller is moved to the right or left of its central position, and this movement is repeated by the indicator. The whole mechanism is simple, and the only complication is the shaping of the crank S adopted in order to admit of an adjustment of the roller radius for compensating any variation in the elasticity of the springs H S. The roller R is set to the right radius by springing the crank inwards or outwards by means of the small screws (Fig. 1); R is then locked, and needs no further adjustment even when the diaphragm is changed.

One of the special features of the instrument is that this change of diaphragm can be made without affecting the calibration of the instrument; the calibration is effected under water pressure. To change the diaphragm D, it is only necessary to remove the nut N_1 (Fig. 1) which holds the spring $H S_2$ in place, and further to remove the right-hand casting F; the nut N_2 having been undone, the diaphragm can

EDWARDS' 54-IN. AUTOMATIC STOP-VALVE.

CONSTRUCTED BY MESSRS. J. BLAKEBOROUGH AND SONS, LIMITED, ENGINEERS, BRIGHOUSE, YORKS.

Fig. 1.

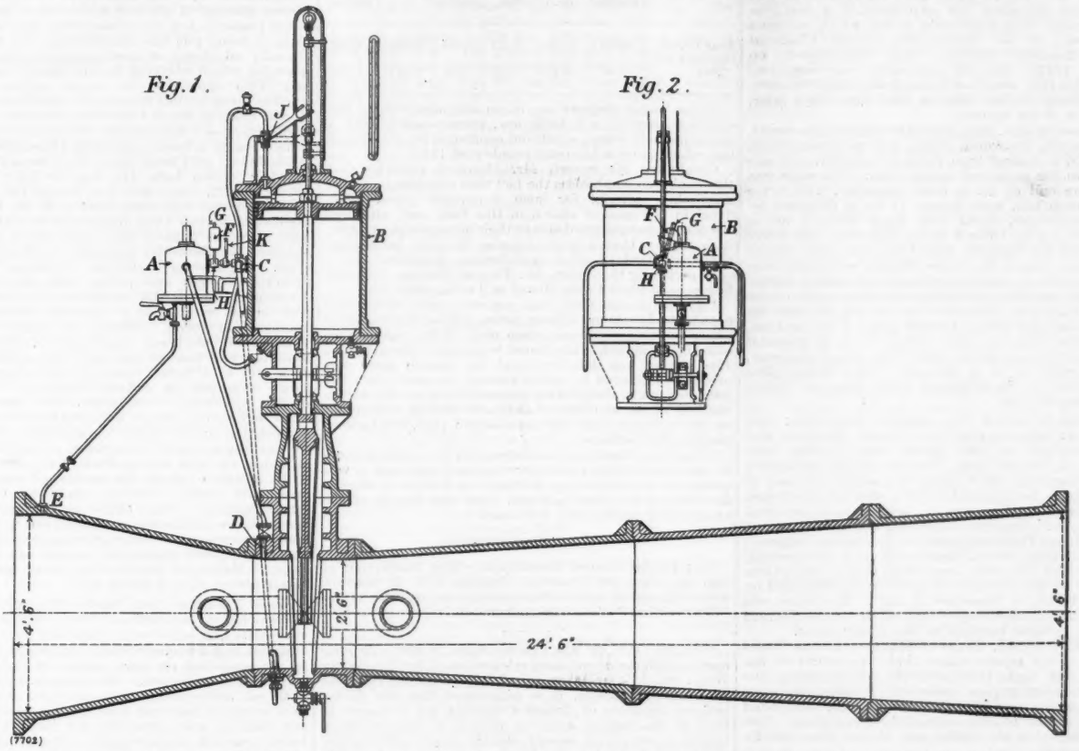


Fig. 2.

(7702)

then be taken out. The spring anchor which the nut N_1 fixes is tapped internally so that a wire can be threaded into it as well as through the casting F and the nut N_1, when this latter is being replaced. The instrument is set to zero by unscrewing the cap A (Fig. 1) and by turning the nuts covered by the cap. The instrument can be equalised in order to check the zero by opening the valve V, after closing the two plug cocks P V (Fig. 1). Any air in the meter finds an outlet through the air vent A V, when the equalising valve V is opened; by these means both sides of the diaphragm can be freed from air. The motion of the crank at the end of the gland spindle is taken out to the pointer through a hat-leather gland L (Fig. 3), which will last for years without requiring any attention. The gland spindle itself is carried in a separate casting which is easily removed for inspection at any time.

The main advantages of the new indicator are its easy installation and adjustment. There is no mercury, and the only adjustment that has to be made after the instrument leaves the work concerns the zero. That adjustment, as we mentioned, is effected by the aid of the nuts at A, which in the latest types of the meter are operated from outside through a gland. The diaphragm D is not liable to be damaged in any way. The handles of the plug cocks P V are so arranged that the down-stream cock $P V_2$ must be thrown open before the up-stream cock $P V_1$ can be opened, and the diaphragm is supported on the ring shown in Figs. 1 and 2 while the pressure is being turned on. If the diaphragm should fail, however, it can easily be replaced even by unskilled hands in a few minutes, without interfering with the adjustment of the instrument.

The indicator scale is sufficiently large to take readings from a considerable distance. The meters are guaranteed to work within ± 2 per cent. absolute accuracy at full load, and within 2½ per cent. at half-load. The instrument installed at West Brompton has not yet been checked by tests; more orifices are being added at that station, however, and control tests are soon to take place. The accuracy realised with similar instruments of Messrs. Kent at the Hackney refuse destructor plant reaches 1 per cent., we understand. By means of a fitting, not shown on our diagrams, one of these indicators can be joined to several orifices.

EDWARDS' AUTOMATIC STOP VALVE.

AN automatic device to prevent excessive flows of water through a main, which is constructed by Messrs. J. Blakeborough and Sons, Limited, of Brighouse, under Edwards' patents, is illustrated in Figs. 1 and 2 on this page.

The design of this automatic stop-valve is such as to ensure reliability and positive action, combined with the means for ready adjustment to suit a change in requirements. The closing action takes place quickly, during the first three-quarters of the travel, but is slowed down in the final stages. This obviates the necessity for large air valves.

The drawings, in Figs. 1 and 2, illustrate a valve suitable for a main 54-in. diameter. The valve is situated at the point of maximum contraction in a Venturi pipe, and the pressure drop is used to actuate an arrangement of trip gear, which controls the cock, C, through which the supply at full pressure is applied to a piston in a hydraulic cylinder B which is directly connected to the main valve. The use of the Venturi principle makes possible the accurate adjustment necessary to ensure closing at any desired rate of flow.

When the valve is set for action to operate at any predetermined rate of flow, the piston in cylinder A is at the bottom of its stroke, and that in the main cylinder B at the top. The space above the piston in cylinder A is in direct communication through the cock C with the point of greatest constriction D in the Venturi pipe, while below the piston the full pressure in the main at E is operative. Between these two pressures there is a difference depending on the rate of flow. When this difference attains the value at which the gear is set to close the valve, the weight F on the lever G is no longer able to hold the piston in the cylinder A at the bottom of the stroke. As the weight F falls sufficiently, its movement is used to reverse the four-way cock C, with the result that the full main pressure is applied at the top of the cylinder B and the exhaust for the other end is fully opened. The piston increases in speed for a time, but is later retarded in its motion by the closing of the cock J, which is operated by a pin on the tail rod of the hydraulic piston. During the last quarter of the stroke the speed of movement of the piston is continuously reduced until the point of complete shut-off is reached.

To re-set the stop-valve, the pressure on the two sides of the main valve is equalised. The lever controlling the motion of the four-way cock C is pulled over to its original position and is followed by the upward movement of the piston in the cylinder B under the action of the hydraulic pressure below it. The main valve is thus re-opened, and the piston in the small cylinder A is forced to the bottom of its stroke, the weighted lever G holding it in position as long as the pressure difference due to the rate of flow does not exceed the critical value.

When it is desired to change the rate of flow at which the valve will operate, the weight F is raised on its lever for an increase and lowered for a decrease. By the calibration of the lever G a scale may be obtained for the position of the weight F for any desired flow.

To ensure the closing of the valve if a burst takes place, a Pitot tube is fitted to face the flow in the contracted area, and is connected through the four-way cock C with the upper side of the hydraulic cylinder B. Should the main burst, the dynamic force due to the velocity of the water induces a pitot head of sufficient magnitude to start the motion of the piston in the hydraulic cylinder and cause it to begin to shut. As it closes, the static pressure on the main begins to rise and the piston speed is at once accelerated.

The main valve is of the wedge-door penstock type, with gunmetal jointing strips on both body and slide. The piston rod of the main cylinder is extended and provided with a pointer and scale to show the position of the valve. Both hydraulic cylinders are lined with gunmetal, all the pipes are of copper and cocks of gunmetal, and copper bushes are inserted in all holes drilled in the cast-iron walls or covers to prevent corrosion.

FARADAY MEDAL.—The Council of the Institution of Electrical Engineers have made the second award of the Faraday medal to the Hon. Sir Charles Algernon Parsons, K.C.B., F.R.S., honorary member of the Institution. The medal is awarded for "notable scientific or industrial achievement in electrical engineering, or for conspicuous service rendered to the advancement of electrical science."

DIESEL ENGINE USERS' ASSOCIATION.—At the next meeting of the Association, on Friday, March 2, at the Institution of Electrical Engineers, the subject of "Heavy Oil Engine Working Costs" is to be considered and discussed. The Association has collected data of the actual working costs of a large number of Diesel and Semi-Diesel engine installations during the last few years, and the committee will be making a report to serve as a basis for a discussion of the whole subject and invite general suggestions from the members as to the most useful purpose to which the information already collected can be put, as well as any further figures which it is proposed to collect from year to year. Non-members interested in the subject and desirous of attending the meeting can make application for tickets of admission to the Honorary Secretary of the Association, at 19, Cadogan Gardens, London, S.W. 3.

EXPLOSION OF A CAST-IRON CONNECTING PIPE.

A PRELIMINARY inquiry has been made by the Board of Trade, under the provisions of the Boiler Explosions Acts, 1882 and 1890, with regard to the cause and circumstances attending the explosion of a cast-iron connecting pipe on a water-tube boiler, which occurred at the works of the Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, on August 8, 1922. By the explosion, one employee, Richard Wheatley, who was working as a coal trimmer, was so seriously scalded that he died three days later, as the result of his injuries.

The connecting pipe, from which the explosion occurred, coupled the two horizontal steam and water drums on a Babcock-Wilcox land type water-tube boiler, and was connected to the saturated steam main. The pipe was 5 in. in bore and 6¾ in. in outer diameter, with a tee branch at each end, with flanges 11 in. in diameter by 1½ in. in thickness, fitted with eight bolts, ⅞ in. in diameter, on a pitch circle 9 in. in diameter. The lower flanges of the tee branches were jointed to pads on the steam drums, whilst the upper flanges were each connected to a set of double spring-loaded safety valves. The distance between the centres of the tee ends of the pipe was 6 ft. 11½ in. At a distance of 19¾ in. from the right-hand tee end was a branch piece, 4 in. in bore, 5½ in. in outer diameter, with a flange 10 in. in diameter by 1 1/16 in. in thickness, having eight bolts, ⅞ in. in diameter, on a pitch circle 8¼ in. in diameter. This branch-piece was connected to the saturated steam main by means of a steel branch pipe.

The boiler, of which this cast-iron connecting pipe formed part, was supplied by Messrs. Babcock and Wilcox, Limited, in 1903, since when it had been practically in constant use. The age of the connecting pipe was, therefore, about nineteen years at the time of the explosion. No repairs had been effected other than rejointing, and small repairs to the boiler, as required. The boiler, including the connecting pipe, was insured with the Vulcan Boiler and General Insurance Company, Limited, 67, King-street, Manchester, and was periodically examined by their inspectors, recent inspections being made by Mr. Cowin on November 16, 1921, and by Mr. R. W. Webb, on December 3, 1921. The boiler was also under the constant supervision of Mr. James Edward Brown, the general foreman of the power plant.

Mr. E. F. Moroney, Engineer-Surveyor to the Board of Trade, in his report states that the nature of the explosion was such that without any warning, the cast-iron connecting pipe broke off immediately below the flange which was joined to the wrought steel bend conveying steam to the saturated steam main. The steam pressure on the boiler was at the time 155 lb. per square inch.

The explosion was caused by fatigue of the cast-iron pipe, due to stresses set up by expansion and contraction of the main steam pipe, working over a period of nineteen years. A flaw about 2 in. long of spongy metal in the casting added to the weakness. The joint being made with jointing material inside the bolt circle only, would probably cause the flange to be stressed considerably. The combination of circumstances resulted in the failure of the pipe.

In his "General Remarks," Mr. Moroney states the boiler of which the cast-iron connecting steam pipe in question formed part was known as No. 6. There were eight similar boilers in the power-house of the Babcock-Wilcox water-tube land type. When installed in 1903, it was tested by hydraulic pressure to 300 lb. per square inch. At that time, the owners were the British Westinghouse Electrical and Manufacturing Company, Limited. The boiler had worked continuously and satisfactorily until the date of the explosion. Superheaters were added in March, 1920, and new safety valves of the spring-loaded type made by Messrs. J. Hopkinson and Co., Limited, of Huddersfield, were fitted in November, 1921. The working pressure of 180 lb. per square inch was maintained throughout. The power-house plant was originally fitted with four boilers, Nos. 1, 2, 3 and 4. In 1903, boilers Nos. 5 and 6 were added. Nos. 1 and 2 were originally fitted with superheaters, and the remainder were for saturated steam only. In 1906, Nos. 7 and 8 boilers were added. These also had superheaters. In March, 1920, boilers Nos. 3, 4, 5 and 6 had superheaters fitted, and at that time the whole of the fittings on the steam range were removed and tested. All pipes and fittings of cast-iron that would be subjected to superheated steam were removed and replaced by wrought steel pipes and steel castings. The pipe from which the explosion occurred was allowed to remain, although it was known to be of cast-iron, but it was subjected to saturated steam only.

Connecting pipes of cast-iron, the report states, were commonly fitted by the makers when these boilers were installed, although they are now discarded for welded steel pipes in this position. The practice of making the joint with a ring of jointing material inside the bolts only appears to be common, and it was followed in this case. The danger of this, owing to the great stresses which can be induced in a flange of such brittle material as cast-iron, on screwing up after making the joint, does not appear to be generally appreciated, and it is quite possible that the material of the pipe was unduly stressed in this case. Further, the stresses induced by the expansion and contraction of the main steam range, which was free to move, and was joined to the connecting pipe by a stiff branch pipe, 6 ft. 6 in. in length, would be very severe at the neck of the fixed cast-iron pipe. After the accident, a flaw was found to have existed in the neck of the casting.

A scientific investigation of the material was made by Mr. R. W. Bailey, B.Sc., Wh.Sch., who is in charge of the metallurgy section of the research department for the owners. The following is an extract from Mr. Bailey's report showing the results of his analyses of the material:

Position.	Combined Carbon	Graphite.	Silicon.	Manganese.	Sulphur	Phosphorus.
Near defect..	0·34	3·08	2·23	0·65	0·068	0·80
Opposite defect ..	0·37	2·97	2·25	0·65	0·071	0·83

"The above analyses are in no way abnormal. The combined carbon is a little low, corresponding with a somewhat soft iron, a condition confirmed by the Brinell test which gave a hardness number of 131."

Concluding his report, Mr. Moroney remarks that this explosion emphasises the fact that cast-iron is a most unsuitable material for such important pipes, when fitted in the manner shown in this case, and, although the makers have discarded it in their more recent practice, it is known that a large number of such boilers are similarly fitted in other installations elsewhere.

In reviewing the report, Mr. Thomas Carlton, Engineer Surveyor-in-Chief to the Board of Trade, states:—

"The explosion from this cast-iron pipe, which had been in use for about nineteen years, and failed apparently under working conditions when none of the valves were being manipulated, is attributed to fatigue of the material. The casting was defective, and the branch piece was probably subjected to undue stresses imposed when the joint was made, the jointing material being wholly within the bolt circle, and also to alternate stresses consequent on the movements of the main steam pipe, due to temperature fluctuations.

"Reference has been made frequently in these reports to the unreliability of cast-iron steam pipes, and it was unfortunate that the pipe that has now failed was allowed to remain when other cast-iron pipes and fittings of the system were replaced by steel ones."

GAS INVESTIGATION COMMITTEE.—The Institution of Gas Engineers, 28, Grosvenor Gardens, S.W. 1, has now issued the eighth report of the committee, on tests of the "Fairweather" recording calorimeter.

BICENTENARY OF SIR CHRISTOPHER WREN.—In connection with the bicentenary celebration of Sir Christopher Wren, which is being organised by the Royal Institute of British Architects, it is announced that the Architectural Institute of British Columbia has arranged to hold in the largest Anglican church in Vancouver, a memorial service on exactly similar lines to the service which will be held in St. Paul's Cathedral on the 26th inst.

NEW FREEBOARD REGULATIONS.—In a paper read before a meeting of the Institution of Engineers and Shipbuilders in Scotland on February 13, Mr. Alexander Chisholm discussed the many changes that have been made at different times in the Board of Trade regulations regarding the allowable freeboard for sea-going vessels. The proposals put forward by the International Committee which met in London in May, 1922, regarding the shelter-deck type of ship and the general question of the allowances made in the tables for superstructure spaces and the various types of closing appliances, were also reviewed.

LONDON TRAFFIC.—The number of passengers carried by the London Underground Transport Undertakings (tubes and 'buses, and exclusive of tramways) for the year 1922, amounted to no less than 1,171,927,766. This represents an increase of 72,049,844 passengers over 1921, no doubt constituting a record. The number of car-miles run amounted to 163,401,602, being an increase of 7,555,618 over 1921. In 1922, London's Underground ran in daily service, 1,480 passenger cars on its railways, and 2,800 omnibuses on the streets of London. No less than 1,344,000*l.* was expended during this year in the provision of new rolling-stock, constructional improvements and extensions of the railways. The companies are committed to an expenditure of 17,000,000*l.* for widespread improvements in Greater London traffic facilities.

MERCHANT VESSELS LOST, CONDEMNED, &C.—The total tonnage of merchant shipping lost, condemned as the result of damage, or removed from the Register Book from other accidental causes during the quarter ended September 30 last, amounted to 124,945 tons and included 113 steamers, motor ships and sailing vessels. As would be expected, the highest individual loss was sustained by Great Britain and Ireland, the figures for these countries including 20 ships making 27,297 tons in the aggregate; the tonnage lost is, however, only 0·14 per cent. of the total tonnage owned by Great Britain and Ireland. The figures for the United States are 17 vessels lost making 13,939 tons, the latter figure representing 0·09 per cent. of the total American sea-going tonnage. French losses during the quarter were comparatively heavy, amounting to 13,918 tons, comprised in 11 ships, and the tonnage representing 0·36 per cent. of the French total. For Japan, Germany and Spain, the tonnage losses were 10,458, 9,954 and 9,791, respectively, and the Spanish losses, it may be mentioned, are relatively heavier than those of any other country, viz., 0·76 per cent. of the total. The figures quoted above are taken from returns just issued by Lloyd's Register of Shipping, which, it will be remembered, does not include vessels of less than 100 gross tons; the tonnages are "gross" in all cases.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Now that prices are definitely in the ascendant makers of finished materials and machinery are coming forward much more freely in order to cover commitments over the next three to six months. The current scarcity of pig-iron and scrap is impeding work at the furnaces, but notwithstanding this disability more plant is being put into commission, and the output of virtually all classes of steels, not excepting the special steels for which Sheffield largely caters, shows a steady rise. This expansion in output embraces not only crucible furnaces, but furnaces of the open-hearth type, several more of which have been restarted in the South Yorkshire area. The scarcity of common iron is reflected in an advance in basic qualities to 5*l.* 5*s.* per ton delivered in Sheffield. Soft steel billets have accordingly risen to 8*l.* 15*s.*; crown bars, 11*l.* 10*s.* to 12*l.*; steel hoops, 12*l.* 5*s.* to 12*l.* 15*s.*; and iron hoops, 14*l.* to 15*l.* Soft steel billets are nominally quoted at 8*l.* 15*s.*, but it is impossible to buy large quantities at this figure. The bulk of orders booked this week are at a level which represent a substantial premium in official basis quotations. Engineering activities continue to expand. Foundries, forges and rolling mills are working less irregularly, though the uncertainty of the Continental position has resulted in a temporary setback in French purchases of rolled material on automobile account. Textile and electrical machinery continue profitable branches, and there is also more movement in machine tools and to a minor extent in agricultural machinery parts. Business in railway material is consistently on the up-grade. More orders have been booked for axles and tyres, though Birmingham is offering severe competition in coil spring manufacture at cheap rates. Private wagon owners have placed a considerable tonnage of orders for new rolling-stock, but prices will require to be adjusted before this section of business shows a reasonable profit. Uneven conditions obtain in the lighter sections. Some of the tool manufacturing firms which have cultivated a connection with the newer markets overseas are doing a moderate business. Further orders have been placed for circular and hand saws for Japan. Makers of files for the cutlery trade are rather better placed than a month ago.

South Yorkshire Coal Trade.—The advent of severe weather has given a welcome fillip to house coal business. Merchants and collieries are now well booked up in best qualities, and a stronger tone is evident in inferior grades. At the same time the gross volume of purchases leaves a good deal to be desired. Steam hards are a busy section, both on home and export account. Prices continue firm mostly at last week's level. The tonnage of furnace and foundry coke available for local disposal is well below current requirements. Premiums are readily obtained for special lots. Slacks and smalls are a moderate market. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 21*s.* to 22*s.*; Derbyshire hards, 20*s.* to 21*s.*; rough slacks, 9*s.* 6*d.* to 11*s.*; nutty slacks, 7*s.* 9*d.* to 9*s.* 9*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Cleveland pig-iron has become almost unpurchasable for anything like early delivery. Most makers are fully sold to the end of April, and are not at all disposed to commit themselves further ahead, with the result that at present business is restricted to sales of small odd lots that come on the market from time to time, and which readily realise higher rates than have ruled since the end of 1921. A trifling parcel of No. 1 has been disposed of at 120*s.*, but it is very doubtful whether that price would again be accepted. No. 3 is 115*s.* to 117*s.* 6*d.*, and No. 4 foundry 110*s.* to 112*s.* Other qualities of Cleveland pig-iron are not quoted.

Hematite.—East Coast hematite has become almost as scarce as Cleveland pig-iron and is in large and growing demand both for home use and for export, customers who used to take Cleveland sorts now buying hematite because of its comparative great cheapness. Germany, Italy and America are still in the market to buy. An upward movement this week is only what was fully expected. The minimum price of Nos. 1, 2 and 3 is now 110*s.*, and many makers who have sold as much iron as they care to dispose of ask a much higher figure.

Foreign Ore.—Inquiries for foreign ore are somewhat better, and prices tend upward, but sales are not on an extensive scale. Best rubio is put at 25*s.* 6*d.* c.i.f. Tees, and good Mediterannean ores are in the neighbourhood of 24*s.* 6*d.* c.i.f. Tees.

Blast-Furnace Coke.—Actual shortage of Durham blast-furnace coke is causing anxiety to local consumers, though there are sellers who are anxious to do what they can to supply old customers with essential needs, and in some cases are doing so at prices greatly below the very high figures ruling for export trade.

Cleveland Ironstone Miners' Hours.—By a majority of only 130 the Cleveland ironstone miners have refused to comply with the mineowners' request to revert to the 8-hours' working day. The owners offered certain advances upon the lower-paid workers' base rates, such advances being contingent upon agreement being reached with regard to a longer working day.

Manufactured Iron and Steel.—Good inquiries continue to circulate for many descriptions of manufactured iron

and steel, but in some branches demand is not so pressing as it has been. Common iron bars are 11*l.*; iron rivets, 11*l.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* 10*s.*; steel angles, 9*l.*; steel rivets, 12*l.* 7*s.* 6*d.*; steel billets, 8*l.* 10*s.* to 9*l.* 5*s.*, according to quality; heavy steel rails, 9*l.* 10*s.*; fish plates, 13*l.* 10*s.*; black sheets, 13*l.* 10*s.*; and galvanised corrugated sheets, 19*l.* 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—In the Scottish steel trade the improvement which was anticipated and appeared to be coming along, has been somewhat retarded as the result of the unsettled conditions now ruling on the Continent. Bookings, which have been fairly good of late, have ensured a steady running of plant in the meantime, but with the cost of construction having gone up and probably advancing still further shortly, the position is slightly obscure. The net consequence is that sellers, while desirous of securing more business, are reluctant to book any distance ahead, except at enhanced prices. On the other hand, buyers do not like the prices now being asked for supplies, and are holding back their orders in all but urgent cases. The day-to-day demand is, on the whole, quite good, and if the outlook would only clear a little there is the prospect of some very satisfactory business being fixed up. The export trade is gradually getting better, and some overseas buyers, fearing delays in delivery of orders already given to Continental firms, have lately been placing orders here. The current quotations are as follow:—Boiler plates, 12*l.* per ton; ship plates, 9*l.* 5*s.* per ton; sections, 9*l.* per ton; and sheets, 11*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—There has been little change of any note in the malleable-iron trade of the West of Scotland over the week, but the outlook is not too promising at the moment. The work on hand generally amounts to a fair tonnage, but there has been a falling-off in forward business, due partly to the unsettlement caused by the Continental position. Managements are hopeful, however, that the conditions will improve before long, and that the demand will be more pronounced, and will expand as freely as during the past couple of months. Prices are firm with "crown" bars still quoted at 11*l.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—A firm to strong tone prevails in the Scottish pig-iron trade at the moment and everything seems to point to such a state continuing. The present output is, of course, not anything like what it could be, but it is being readily disposed of to consumers. With the steel trade gradually expanding, the demand for hematite has improved steadily, while that for foundry grades is also considerably better. The furnaces in blast are turning out a fairly large tonnage, and more would be put into blast were it not for the difficult conditions to be faced at present. Raw material and fuel have gone up considerably, and that, coupled with the good demand prevailing, both on home and export account, has firmed up quotations. To-day's prices may be taken as under:—Hematite iron, 5*l.* 10*s.* per ton, delivered at the steel works; foundry iron, No. 1, 5*l.* 12*s.* 6*d.* per ton; and No. 3, 5*l.* 7*s.* 6*d.* per ton, at makers' works.

Scottish Pig-Iron Shipments.—The total amount of Scottish pig-iron shipped from Glasgow Harbour for the week ending Saturday, February 17, was 6,912 tons, of which 6,732 tons went foreign. For the corresponding week last year, the total was 607 tons, of which 555 tons went foreign.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The question of deciding whether a third shift should be worked by the coal trimmers and tippers at the South Wales ports is to go to a Court of Inquiry. Protracted negotiations between representatives of the coal owners, exporters, shipowners, railway and dock owners and the coal trimmers and tippers have failed to reach a settlement, and the employers' representatives have intimated that they must apply to the Industrial Court for an inquiry in accordance with the following finding of the Court made in June, 1920—"That there be reserved to the employers the right to claim that a third shift be put on should the requirements of the trade warrant it; the necessity of this (in case of difference) to be referred to a Court of Inquiry to be constituted under the Industrial Courts Act, 1919." It was not until the beginning of this year that the employers and men came to grips on the matter, though the traders have for the past twelve months pointed out the desirability of an extension of hours. A joint sub-committee investigated the conditions at the various ports, and subsequently the employers submitted a proposal for a split day and night shift, involving in each case a 48 hours working week. This the men rejected, and put forward a counter-proposal for a partial third shift, subject to guarantees and safeguards to prevent the existing earnings being reduced, the men on the night shift to receive the same amount as those on the morning and afternoon shifts. The employers rejected the proposal, contending that the industry was one of mutual interest and benefit to all parties, and that it was unreasonable to ask for a guarantee based on the present abnormal pressure for coal. The matter is now to go before a Court of Inquiry, and it is not expected that any decision will be reached for at least three months. Meanwhile shipping congestion is seriously handicapping traders. Yesterday there were no less than 54 vessels waiting for loading berths at the Cardiff, Penarth, Barry and Newport docks, and to-day there were 51. These totals do not take into account the tonnage waiting for orders or for coal from the collieries. An illustration of the varied position of collieries will be gathered from the fact that whereas one company with 22 vessels for cargoes and bunkers had six boats in loading berths, another with 30 steamers, had 15 under the tip. The former firm had not sufficient boats in berth to absorb available outputs, while the other had more than it could cope with. The general position of the market is firm. Inquiries are numerous, especially from Germany, and for best large coal, 29*s.* to 30*s.* is demanded. Smalls of all classes are especially scarce, and for best steams 22*s.* to 23*s.* can be secured, and even ordinary qualities command 18*s.* There is an urgent demand for coke from Germany and France. The export price of foundry coke has jumped from 45*s.* to 55*s.*, and for furnace coke from 35*s.* to 45*s.* with sellers now demanding 60*s.* and 50*s.* respectively.

ROYAL INSTITUTE OF BRITISH ARCHITECTS.—Public lectures on architecture are to be delivered in the Large Gallery of the Royal Institute of British Architects in February and March, in continuation of the series delivered during the last two years. The object of the lectures is to promote a more general interest in architecture. The secretary will send admission cards on application to him addressed 9, Conduit-street Hanover-square, W. 1.

INTERNATIONAL CONGRESS FOR TOWN PLANNING AND MUNICIPAL HYGIENE.—This congress is to be held in Strasburg, from July 15 to 18, both dates inclusive. The British patrons are the Institution of Civil Engineers, the Institution of Municipal and County Engineers, the Royal Sanitary Institute and the Royal Institute of British Architects. There are to be four sections, dealing with Legislation, Town Planning, Hygiene, and Dwelling-House Construction. The offices of the committee are 10, Rue Lavoisier, Paris.

THE INSTITUTION OF MECHANICAL ENGINEERS' CONVERSAZIONE.—The annual conversazione of the Institution of Mechanical Engineers was held on Thursday, the 15th inst. Owing to the accommodation of the Institution House at Storey's-gate having proved uncomfortably crowded on recent occasions of this character, arrangements were made this year, through the courtesy of the Delegacy, to hold it at the City and Guilds (Engineering) College, at South Kensington. The guests were received by the President, Dr. Hele Shaw, and Mrs. Hele Shaw, supported by a number of Members of Council. Altogether some 350 members of the Institution and friends attended the function. During the evening demonstrations were given on the apparatus and machinery in the laboratories, under the direction of the Dean of the College, Prof. W. E. Dalby.

RAILWAY PASSENGER STATIONS.—A lecture on the subject of "The Modernisation of Passenger Railway Stations" was delivered on Monday last before the graduates and students of the Institute of Transport, by Mr. F. Bushrod and Mr. J. F. S. Tyler. In this lecture, the authors gave examples of typical modern stations of the usual character for dealing with ordinary traffic, and also of special lay-outs where traffic of a particular kind had to be provided for. After describing and illustrating a number of stations to bring out various points, the authors discussed the general arrangement of station offices, etc., passing subsequently to the question of locomotive and carriage facilities in connection with stations. They argued in favour of general standard designs which should lead to economy, and within limits should prove practicable in the large groups now formed. Standardisation, it may be stated, is carried much further in this connection in the United States than it is here. The lecture terminated with a discussion of the important question of the siting of signals and its influence on station lay-out and the general effect on the expeditious handling of traffic.

PERSONAL.—Mr. E. J. Silcock, M.Inst.C.E., announces that he has removed his London office from 17, Victoria-street, to 25, Victoria-street, Westminster.—Fry's Metal Foundry, 25 to 42, Holland-street, Blackfriars, S.E. 1, are continuing to do very valuable work in educating the trades which they serve on technical problems connected with "Printing Metals" and "White Anti-friction Metals." During 1922, Mr. A. H. Mundey, their London manager, as well as other members of the staff, gave more than 20 lectures on metals in various parts of the United Kingdom.—In accordance with the terms of a special resolutionp, assed at an extraordinary general meeting of the members of the Company, held on December 27, and confirmed at an extraordinary general meeting, held on January 15, the name of William Platts and Company Limited, has been discontinued, and this Company in future will be known as the "Whitby Shipbuilding Company, Limited." The directors are:—Mr. C. J. Wilson, chairman, Mr. Claude S. Norton, Mr. H. W. Smales, Mr. A. L. Sutcliffe, and Mr. E. B. John, M.I.N.A., managing director.—The Scottish Tube Company, Limited, 34, Robertson-street, Glasgow, have opened new branch offices and warehouses in Port Elizabeth and East London, South Africa. The Port Elizabeth office and warehouse are situated at 18, South-street, and those of East London at 22, Union Street.—The Brush Electrical Engineering, Company, Limited, Falcon Works, Loughborough, state that the address of their London office and registered office on and after the 26 inst. will be 88, Kingsway, W.C.2, Telephone No.: Holborn, 1220. Telegraphic address: "Magneto, West Cent., London."

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, February 23, at 7.30 p.m., at 39, Victoria-street, S.W. 1. Lecturette, "Characteristics, Operation and Maintenance of Underground Cables," by Mr. A. J. Tracey. Friday, March 2, at 7.30 p.m.: Lecturette, "Glass-Forming Machines," by Mr. C. Saxton.

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, February 23, at 7.30 p.m., at the Engineers' Club, Coventry-street, London, W. 1. Mr. T. F. Hardyman, Yeovil, will read a paper on "Machine Moulding Methods."

THE BRADFORD ENGINEERING SOCIETY.—Monday, February 26, at 7.30 p.m., in the Hall of the Bradford Technical College. Lecture on "Power Production in Relation to Ultimate Values," by Mr. A. Hugh Seabrook, M.I.Mech.E., M.I.E.E.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, February 27, at 6.30 p.m., at 85 to 88, The Minories, Tower-hill, E. 1, "Auxiliary Machinery," by Engineer-Commander R. Beeman, C.M.G., R.N.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, February 27, at 7.30 p.m., in the Rankine Hall, 39, Elmbank-crescent, Glasgow. Lecture on "Wireless Telephony," by Professor G. W. O. Howe, D.Sc.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, February 27, at 6 p.m. Papers to be submitted for further discussion: "Colombo Drainage Works," by Mr. Richard Eustace Tickell, O.B.E., M.Inst.C.E.; "Evolution in Sewage-Disposal, with Special Regard to South African Experience in Sludge-Treatment, particularly at Pretoria," by Mr. Frank Walton Jameson; "Main Drainage of the Southern Suburbs of the City of Cape Town, South Africa," by Mr. David Ernest Lloyd-Davies, M.Inst.C.E. Students' Meeting, Wednesday, February 28, at 6 p.m.: Lecture on "Recent Developments in Wireless Telephony," by Captain H. Riall Sankey, C.B., C.B.E., M.Inst.C.E. Students' visit, Saturday (morning), March 3, to Marconi House.

THE ROYAL SOCIETY OF ARTS.—Wednesday, February 28. "Heat Resisting Glasses," by Professor W. E. S. Turner, O.B.E., D.Sc., F.Inst.P., Head of the Department of Glass Technology, University of Sheffield. The Hon. Charles Algernon Parsons, K.C.B., LL.D., D.Sc., F.R.S., will preside.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, March 1, at 6 p.m., in the Lecture Theatre of the Institution, Savoy-place, Victoria Embankment, W.C. 2. Report presented on behalf of the British Electrical Research Association, by Messrs. S. W. Melsom and E. Fawssett, on "Permissible Loading of British Standard Paper-Insulated Electric Cables."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 2, at 9 p.m., a discourse will be delivered by Mr. George C. Simpson, C.B.E., D.Sc., F.R.S., Director, Meteorological Office. The subject is "The Water in the Atmosphere." Afternoon Lectures, at 3 p.m.: Tuesday, February 27, Sir Arthur E. Shipley, G.B.E., D.Sc., F.R.S., on "Life and its Rhythms: (1) Life and its Attributes"; Thursday, March 1, Mr. Theodore Stevens, B.Met., M.Inst.C.E., M.I.E.E., on "Water Power of the Empire" (Lecture I); Saturday, March 3, Sir Ernest Rutherford, LL.D., D.Sc., F.R.S., M.R.I., Professor of Natural Philosohpy, on "Atomic Projectiles and Their Properties" (Lecture II).

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, March 2, at Bolbec Hall, Newcastle-on-Tyne. Paper by Mr. G. S. Baker on "Measured Mile Trials."

NATIONAL ASSOCIATION OF SUPERVISING ELECTRICIANS AND ASSOCIATION OF ENGINEERS-IN-CHARGE.—A joint lecture on "Preparation of Estimates, Specifications and Contracts for Electrical Work," by Mr. W. E. Highfield, Mr. Alan Kirk and Captain A. E. Penn, is to be delivered on the 27th inst., at 7 p.m., at St. Bride's Institute, Bride-lane, Ludgate Circus, E.C. 4.

BRITISH IRON AND STEEL PRODUCTION.—The National Federation of Iron and Steel Manufacturers state that the production of pig-iron in January amounted to 567,900 tons, compared with 533,700 tons in December and 288,000 tons in January, 1922. Furnaces in blast at the end of January numbered 183, a net increase of 14 during the month. The production includes 186,100 tons of hematite, 180,000 tons of basic, 138,600 tons of foundry and 30,800 tons of forge pig-iron. The output of steel ingots and castings in January amounted to 624,300 tons, the highest total attained since December, 1920.

MARKETING OIL SHALE PRODUCTS.—Under the best possible conditions, because of the capital and construction work required, it must be many years before an oil shale industry begins to assume the magnitude of the present petroleum industry in the United States, and therefore, many years before shale products are extensively marketed, according to Mr. Martin J. Gavin, refinery engineer of the United States Bureau of Mines. Mr. Gavin does not believe that shale-oil products will ever be serious competitors of petroleum products. Shale oil may be expected gradually to replace petroleum as the petroleum supply fails. It seems likely, therefore, that shale-oil products, when they are marketed in considerable quantity, will be marketed through the present systems, and under the conditions used in marketing petroleum.

THE NECHELLS POWER STATION OF THE BIRMINGHAM CORPORATION.

MR. R. A. CHATTOCK, M.I.E.E., CITY ELECTRICAL ENGINEER.

(*For Description, see Page* 227.)

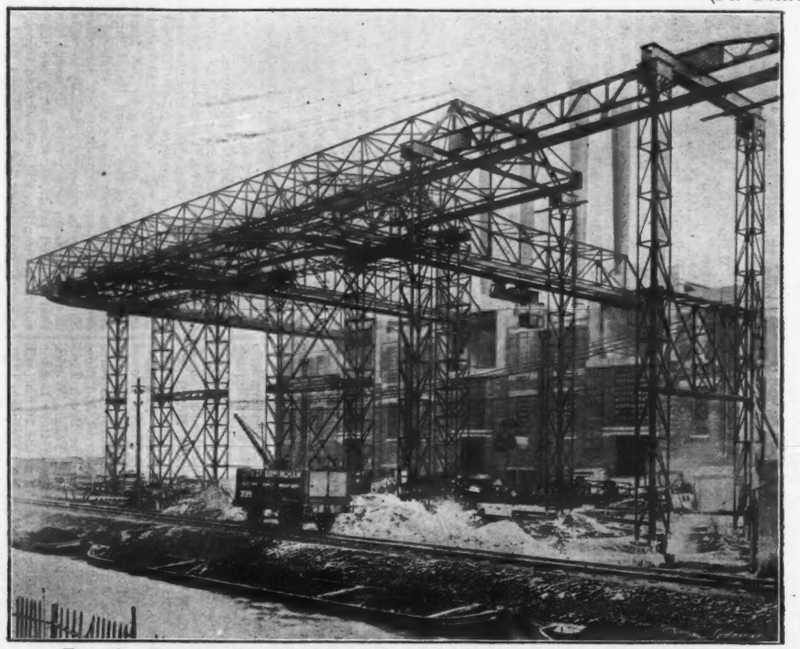


Fig. 59. Telpher Coal-Handling Plant: looking towards Power House.

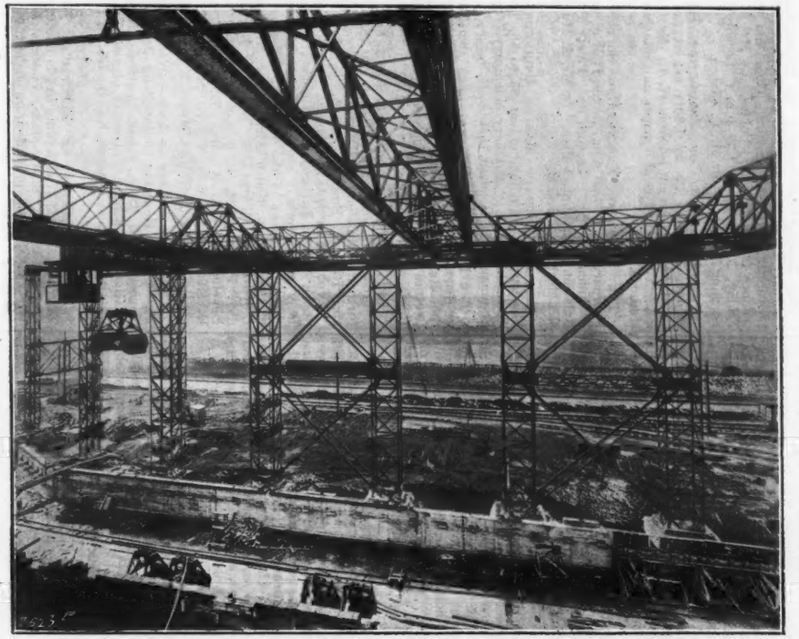


Fig. 60. Telpher Coal-Handling Plant: looking towards Canal.

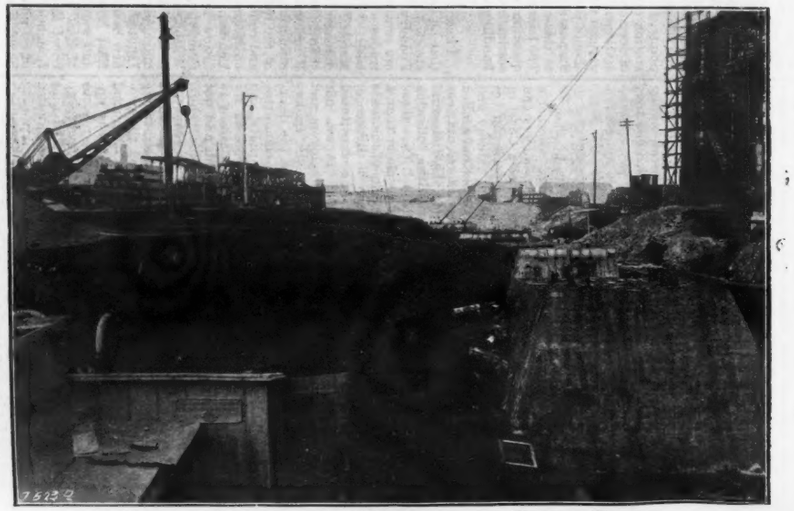


Fig. 61. Mass Concrete Foundations for Telpher Towers.

Fig. 62. Construction of Culvert under Site of Coal-Store.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } **"ENGINEERING," WESTRAND, LONDON.**

TELEPHONE NUMBERS—3663 and 8598 GERRARD.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any newsagent in town and country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	**£3**	**5**	**0**
For Canada—			
Thin paper copies	**£2**	**18**	**6**
Thick paper copies	**£3**	**3**	**0**
For all other places abroad—			
Thin paper copies	**£3**	**3**	**0**
Thick paper copies	**£3**	**7**	**6**

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

ADVERTISEMENT RATES.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

All accounts are payable to ENGINEERING LTD. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Angus and Robertson, Limited, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.

BELGIUM, Brussels: E. F. Satchell, 86, Rue de Tabellion.

CANADA, Toronto, Ont.: Wm. Dawson and Sons, Limited, 87, Queen Street, East.

EDINBURGH: John Menzies and Co., 12, Hanover-street.

FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.

GLASGOW: William Love.

INDIA, Calcutta: Thacker, Spink and Co., Bombay; Thacker and Co., Limited.

ITALY: U. Hoepli, Milan.
Anonima Libraria Italiana, Torino.
And any post office.

LIVERPOOL: Mrs. Taylor, Landing Stages.

MANCHESTER: John Heywood, 143, Deansgate.

NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.

NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.

ROTTERDAM: H. A. Kramer and Son.

SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Wm. Dawson and Sons (South Africa), Limited, 29 and 31, Long-street, Capetown.

TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston: Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 432, Fourth Avenue. For Advertisements: J. S. Allan, 90, Church-street, New York.

CONTENTS.

	PAGE
18-In. Refracting Telescope for the Brazilian Government (*Illus.*)	223
Leakage through Thin Clearance Spaces (*Illus.*)	225
The Nechells Power Station of the Birmingham Corporation (*Illus.*)	227
The Institution of Mechanical Engineers	229
The British Industries Fair at Birmingham (*Illus.*)	230
The British Industries Fair in London	232
Industrial Notes	233
The Kent Boiler Load Indicator (*Illus.*)	234
Edwards' Automatic Stop Valve (*Illus.*)	235
Explosion of a Cast-Iron Connecting Pipe	236
Notes from South Yorkshire	236
Notes from Cleveland and the Northern Counties	236
Notes from the North	237
Notes from the South-West	237
Notices of Meetings	237
Accident Prevention	239
Sewage Treatment in Great Britain and America	240
Unemployment Insurance by Industry	240
Oil Pumping	241
British Trade with Australia	241
Atomic Projectiles and their Properties (*Illus.*)	242
Notes	243
The Late Mr. Adam Scott	245
Notes on New Books	245
Letters to the Editor:—The Torsion of Solid and Hollow Prisms and Cylinders. Modern Turbine Efficiencies. "Rainfall and Floods." Marine Reduction Gearing. "Suggested Specification for Permanent Magnet Steels	246
Some Mechanical Problems in the Rubber Industry (*Illus.*)	247
The Effect of Repetition Stresses on Materials (*Illus.*)	252
Catalogues	254

Two-Page Plate.—DETAILS OF 18-IN. TELESCOPE AT THE NATIONAL OBSERVATORY, RIO DE JANEIRO.

ENGINEERING.

FRIDAY, FEBRUARY 23, 1923.

ACCIDENT PREVENTION.

ACCIDENTS have no doubt accompanied man through his history from the beginning, and may be expected to do so to the end. To say this is not to admit, however, that nothing can be done to control their number, or incidence. Etymologically an accident is anything that happens, and no one is likely to deny that foresight and care may reduce the percentage of things which happen which become accidents in the everyday sense, or mishaps. It is certain that on a carelessly-operated railway on which the regulations are overlooked, or not bothered about, the percentage of accidents per train movement will be greater than on one which is operated with care. If this is admitted it may surely also be admitted that foresight and care may be expected to reduce the number of accidents which happen in our streets. That this apparently obvious conclusion is not generally accepted was, however, illustrated by the ridicule and opposition which the London "Safety First" Council encountered in the course of its early activities. This ridicule may no doubt partly be put down to the name of this organisation, which is certainly not a happy one. It is necessary to remember however that the movement which this council represents is one which it is desired to bring home to the common people, and the common people have no fine literary tastes or distinctions. A catch phrase like "Safety First" is practically a necessity for any movement which is quickly to take a prominent position in the public mind.

The London "Safety First" Council concerns itself with street accidents, and the Metropolitan Police records show that it still has very ample ground for the exercise of its activities. Its sphere is the reduction of what one may call public accidents, and the success of its work, or the enthusiasm which is behind it, has caused an extension of its field to factories and workshops and the formation of an allied body, the "British Industrial 'Safety First' Association." This latter organisation came into being in 1918, so that it now has some few years' work to its credit and some evidence of the value of its activities is available. At first sight it might be thought that although there was work to do in attempting to reduce our deplorable toll of street accidents, there could be little field for the activities of a new outside body inside our workshops, since the ground is already so admirably covered by our system of Home Office factory inspection. That this idea is erroneous is amply shown by the remarkable results which the activities of the association have already led to.

The work of the association is complementary to that of the Home Office Inspectors, and there is no competition. That this is so is sufficiently illustrated by the fact that Mr. Gerald Bellhouse, the Chief Home Office Inspector, is a member of the Executive Committee of the association. The duty of the Home Office inspectors is concerned with what one may call the material side of accident prevention—the provision of suitable guards over moving machinery and the regulation of dangerous operations. The work of the "Safety First" Association lies rather in the mental field. Its purpose is to educate both employer and employee to a better appreciation of care, and the necessity for proper attention to rules intended to help in reducing accidents. To take a very simple example, it is certain that a considerable proportion of our street accidents are directly due to thoughtlessness or the taking of unwarranted risks by pedestrians and the work of the "Safety First" Council is in the direction of educating the public to a better appreciation of the possibilities of improvement which lie in its own hands. The education of the general public in a matter of this kind can only be carried out by some form of advertisement, which is perhaps unfortunate, as it may suggest that what the advertisers are really after is self-advertisement. This idea may be partly responsible for the early prejudice against the "Safety First" Council.

It is difficult to say what effect the work of the "Safety First" Council has had on street accidents. The matter is not easy to estimate, since the conditions of street traffic are continually changing, but on the whole it does not appear that much of importance has yet been achieved. When one turns to factory conditions, however, it is remarkable to find the results which have been obtained from the efforts of the "Safety First" Association. This body, as we have said, was formed in 1918 and the fourth annual report has just been published. The quotation of some figures from that report will illustrate better than anything else that the association really does stand for something definite and that it is neither to be ignored, nor smiled at. The report gives a list of the results achieved by various firms—members of the association. Quoting from this it appears that an engineering firm which has been a member for three and a-half years has reduced the number of accidents in its shops by 76·94 per cent.; a machine tool firm in two years has reduced its accidents by 54·8 per cent.; and a shipbuilding firm in one year has reduced its accidents by 21 per cent. We quote these figures as they relate to engineering works, but many other equally striking are given relating to other industries.

Although as we have said it is the duty of the Home Office factory inspectors to deal with the material side of accident prevention, it is obvious that some machines or some processes in some factories must escape their attention, and it is very probable that a percentage of the accident prevention in the cases we have quoted may be due to a greater attention to the material side of accident prevention by the employers, owing to their interest being specially directed to the subject. Some of the changes which have resulted in improvement would no doubt in due course have been ordered by the factory inspectors. To admit this is in no way to deprecate the work of the "Safety First" Association. If by raising a keener interest in the employer it can prevent accidents, this is all to the good. There is no advantage in waiting for the factory inspector.

Apart from the question of employers' interest, however, there is little doubt but that some, and indeed much, of the improvement is due to the education of the workpeople to a greater care and watchfulness. It is a commonplace of industry that one of the chief troubles of an employer, who

Fig. 61. Mass Concrete Foundations for Telpher Towers.

Fig. 62. Construction of Culvert under Site of Coal-Store.

devotes special attention to matters of health and the prevention of accident in his workshops, lies in the carelessness and indifference of the employees. Such matters as washing the hands after handling poisonous substances before meals are taken, and sometimes even elementary care in the use of machines are difficult and even impossible to enforce, and anything which educates the workpeople to a better appreciation of their own interests in matters of this kind is likely to prevent many accidents which no system of factory inspection can ever achieve. This educative work is the business of the "Safety First" Association, and that its methods are sound is evidenced by the remarkable results it is obtaining.

In the year 1921 there were 285,746 accidents to workpeople in factories and mines in this country, involving a payment of 5,509,395*l.* in Workmen's Compensation. In the opinion of Mr. Gerald Bellhouse, the Chief Inspector of Factories, 75 per cent. of these accidents were preventible, not by the provision of more machine guards, &c., but by the exercise of the care on the part of the employees which it is the business of the "Safety First" Association to foster. In view of figures of this kind and the percentage reductions which member firms of the association are obtaining it will be seen that the question is not only one of an important humanitarian work but that it has a very definite cash value and, as Sir William Joynson-Hicks pointed out at the dinner of the association last Friday, is not to be neglected in a consideration of lowered production costs and overseas trade.

A good deal of attention has been paid to "Safety First" work in America, and some remarkable figures have just been published in connection with the Edgar Thomson Works at Braddock, of the United States Steel Corporation. This is a branch of work to which "Safety First" methods have not yet been applied to any extent in this country, although much has been done in the United States. The accident rate in the Braddock steel mills has been reduced to 7·8 per thousand employees per annum, as compared with 240 per thousand per annum for the average of the United States, while the fatality rate has been reduced by 80 per cent. It is possible that conditions are specially favourable at Braddock, but when a figure of 7·8 is set against 240 it would certainly appear that a position has been established which is worth attention from our steel masters. The "Safety First" Association appears to be now well established, and although it is losing the services of Mr. H. E. Blain, who has acted as hon. secretary from the beginning and has freely lent his great organising ability and energy to the work, there appears no doubt but that its activities will continue and extend. The formation of a national organisation is now being considered which shall co-ordinate the industrial and street work, and bring in the "Safety First" Councils which have already been established in Birmingham, Bristol and Nottingham.

SEWAGE TREATMENT IN GREAT BRITAIN AND AMERICA.

The comparison of outlook of the designers of plant for any specific purpose in different countries is always of great interest. It shows the differing attitude of engineers towards the same problem, not only varying because of contrasting temperaments, but also because of the minute differences found in the various countries in the same problem. These changes, though they may be small in themselves, may be the determining factors between success and failure, unless modifications in practice are introduced. These thoughts are brought to mind in the study of a series of articles on "The Present Status of Sewage Treatment in England," written by Mr. George W. Fuller, which appeared in our American contemporary, *Engineering News-Record*, for February 1, 8 and 15.

The attitude towards sewage treatment problems in Britain shows a marked change now from the period before the war. In those days elaborate schemes, costly in plant, whether economic or not, received sanction on occasion, but such action was later made impossible by the European War, for during its progress all development of sewage schemes was arrested, except in those for the military organisations and for new districts opened up for munitions production. Not only did civil schemes receive scanty consideration, but in addition the efficient and normal working of existing systems was made difficult, if not impossible, by the smallness of the residue of the staff left for the work, augmented only with women and, in some cases, German prisoners. Since the armistice, a great amount of progress has been made in overhauling the plants and putting them back into condition, and in continuing the new work started before the war. Construction costs are, of course, high, and have restricted the amount of new work.

The transfer of control from the Local Government Board to the Ministry of Health in those cases where loans have to be raised, has been marked by few changes in procedure or outlook, the regulations based on the reports of the Royal Commission on Sewage Disposal still being adhered to. The recently introduced activated-sludge treatment has, however, found favour, and loans have been sanctioned in some cases for plant of that type to supplement overloaded equipment of the older classes.

The principal undertaking when the war ended was to wash and restore the filter beds. In connection with this side of the plant it is no simple matter to decide what size of material in the sprinkler beds is most suitable, if clogging at some period of use is to be prevented, but little or no trouble seems to have been experienced when the material was separated from anything that would pass through a $\frac{3}{4}$-in. screen. For reasons of keeping down first costs in British sewage plants, existing works were converted into plant of modern type after the war, wherever conditions made it practicable. Existing contact beds have been converted into the sprinkler type, and activated sludge plants have been installed in available tanks. Economic considerations have compelled the designers of the works to install only plant which can immediately show results comparable with the costs. Chemical precipitation has been in consequence almost completely replaced by ordinary sedimentation. Mr. Fuller, in his articles, shows that he was greatly impressed with the value of the records of working obtained in the various sewage works he visited in this country. The British practice of dealing with the pollution of all the streams in a watershed through one River or Conservancy Board, also won his favour. This system is deserving of close study by the Americans, for in their country there are limitations to effective work through interstate complications and other considerations which are particularly troublesome.

The amount and character of trade waste varies greatly in the different British towns, but the magnitude of its effect upon the quantity and texture of the sludge or the readiness with which it is deposited, are not completely understood. The action of trade waste upon the separation of colloidal matter and the decomposition of organic substances, also, has not been determined.

In America a series of grit channels with a total length of 60 ft. to 100 ft. through which the material flows at from 40 ft. to 60 ft. per minute, replace the small detritus tanks used in Britain. These tanks afford a much greater clarification of the effluent than is obtained with the American grit channels. The British process combined with the removal of the deposit by grabs suits the practice of carrying all the sludge out to sea, pressing it, or trenching it on land. Another essential difference in practice is the use of fine screens by American engineers rather than the mechanically-cleaned racks which we find more suitable. During the war, chemical precipitants were not procurable, and this process has been now abandoned in Britain, as any advantages it possesses are not considered to be comparable with the cost of working. The grease in the wool-scouring mills is, however, cracked with sulphuric acid, but it is a flotation process and not really a precipitation one. Simple contact beds have lost the standing they had in Britain ten to twenty years ago, and are being replaced by sprinkler beds supplemented with large humus tanks.

The activated sludge process is finding extensive use in Britain, although most of the authorities are still carrying on investigations into large-scale working with their first instalment of plant. There are some differences between the process, as carried out in the two countries. The preliminary treatment is carried further in Britain than in America. Nitrification is not sought after in the working of the British plant. An observation which has puzzled many investigators into British sewage working and the results obtained, is that less air is used for the concentrated sewages treated in Britain than with the weaker ones dealt with in America. Mr. Fuller does not attempt a detailed discussion of the matter, but suggests as contributory elements: The fact that British sewages are better clarified, that American plants are operated to produce nitrification to obtain sludge containing the colloids to a greater extent and to promote easy dehydration, and that the metal salts affect the actions on British working considerably. One factor in favour of the introduction of the activated sludge system in Britain, is that in many works the costs are lower than those for restoring the old plant to reasonable condition.

UNEMPLOYMENT INSURANCE BY INDUSTRY.

The problem of unemployment insurance by industry, which has been so much discussed of late, has been approached from many different angles by persons with very different aims and ideals. The pamphlet issued by the National Joint Council representing the Trades Union Congress and the Labour Party shows clearly that the writers' ideal system of insurance by industry is one under which the industry should bear the cost, with or without State assistance, the trade unions should have the control, and the workers should not have to contribute. They recognise that such an ideal is not attainable at present, but from any system which might be adopted they would certainly expect increased rates of benefit, the present rates being in their opinion "ridiculously inadequate for any standard." The immediate aim of the Geddes Committee was to decrease the State's expenditure on unemployment insurance, or at least on its administration, by transferring the burden to industry. Following upon the report of that committee, Sir Montague Barlow, as Minister of Labour, mooted the question generally, as in duty bound. The Ministry of Health, there is reason to believe, would be glad to filch the whole job away from the Ministry of Labour, no doubt under the delusion that it could be adequately done through the approved societies. Also there are employers who are concerned at the present high cost of production, and hope, and would fain believe, that if their industries could provide increased benefits for their unemployed workers, the fear of unemployment which is so often put forward as an excuse for the policy of "Ca' canny" would be diminished, and the policy, or, at least, the excuse, would disappear. That the problem is difficult is admitted by all, and although suggestions for its investigation have been many no one has been able to offer a cut-and-dried solution.

The administration of unemployment insurance could scarcely be taken away altogether from the Labour Exchanges, for even the most complete system would still require to be supplemented by some agency for the registration of vacancies and applicants for work. It has not been suggested, so far as we know, that each industry, on setting up its own insurance fund and arranging its own contributions and benefits, should set up also its own Labour Exchanges, for that would lead merely to the multiplication of Labour Exchanges, and the last state would be worse than the first. It would seem, therefore, that so long as the unemployed are with us, so long must we suffer the State Labour Exchanges or their equivalents.

It is generally admitted that the complete abolition of the State system of unemployment insurance is not feasible. Industries with a low rate of unemployment might be able to bear their own insurance with comparatively little support from the State, but industries with a heavy rate could not do so, and some industries are not sufficiently organised to be able to "contract out" at all. There remains, however, the question whether a highly organised industry such as engineering, which has merely a comparatively moderate rate of unemployment, could contract out; whether it should do so, and if

DETAILS OF 18-IN. TELESCOPE AT THE NATION

CONSTRUCTED BY MESSRS. T. [illegible]KE AND

(For Descripti[illegible]ee Page 2

Fig. 38.

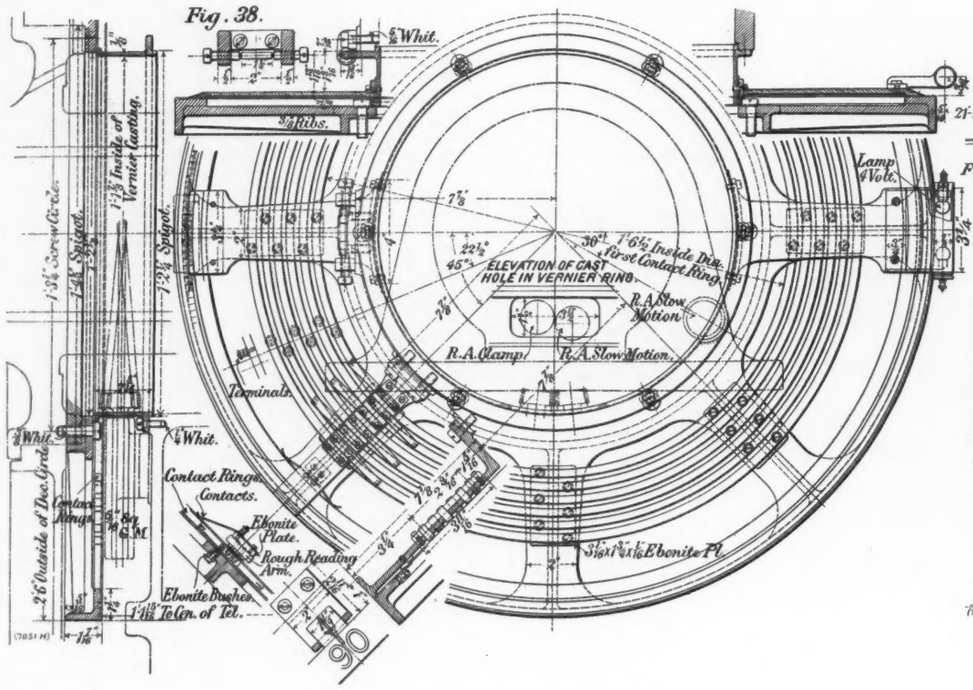


Fig. 39.

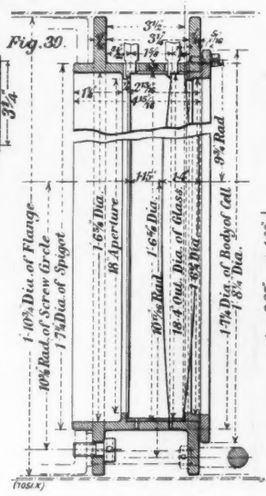


Fig. 40.

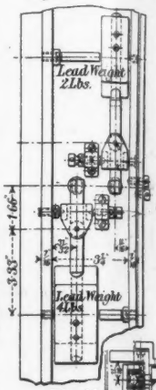


Fig. 41.

Fig. 42.

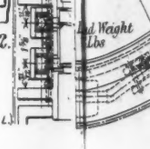


Fig. 43.

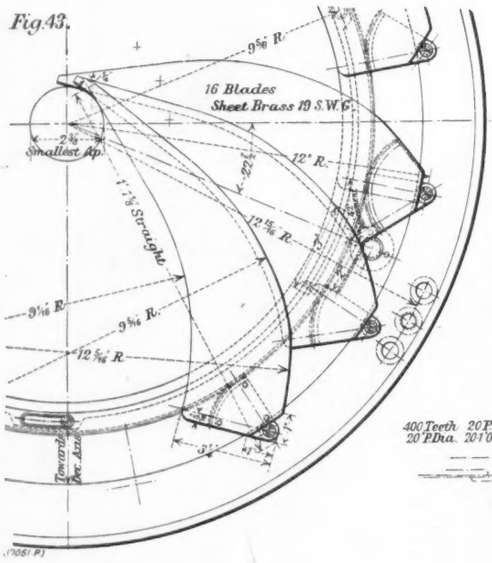


Fig. 44.

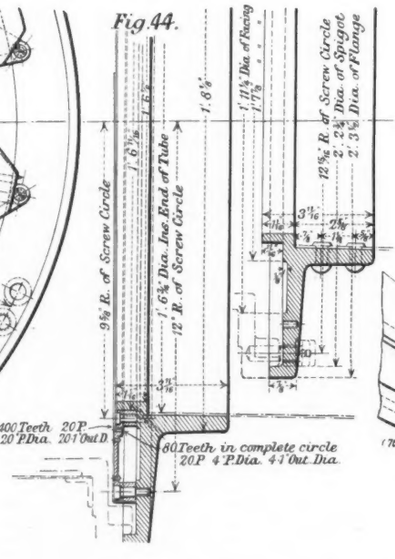


Fig. 45.

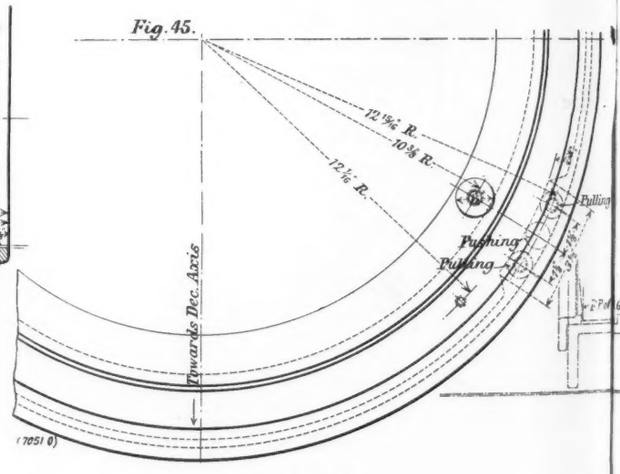


Fig. 49.

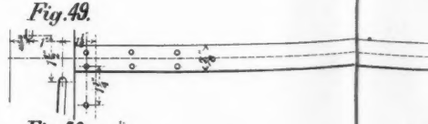


Fig. 50.

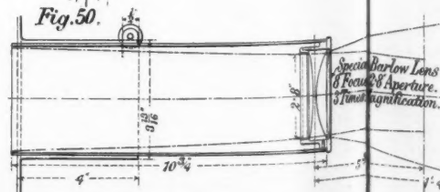


Fig. 47.

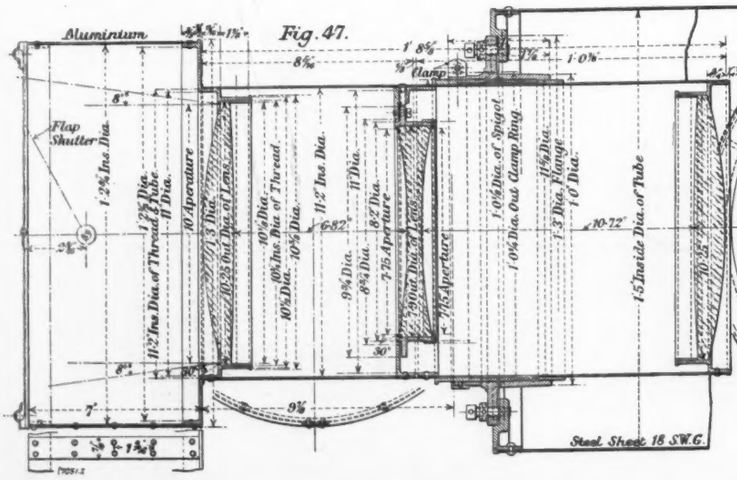


Fig. 48.

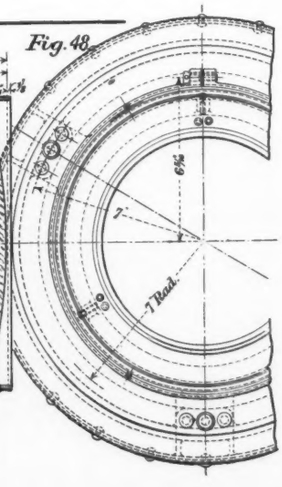
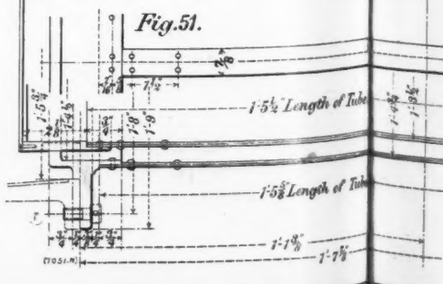


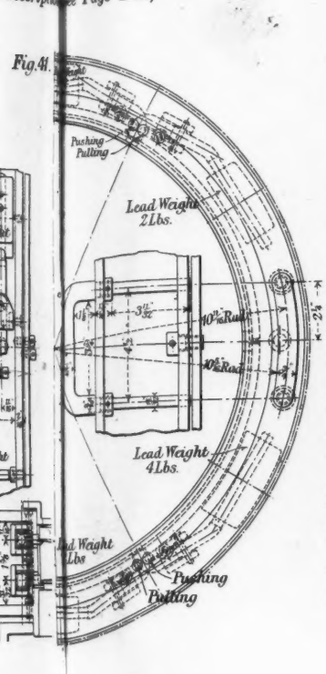
Fig. 51.

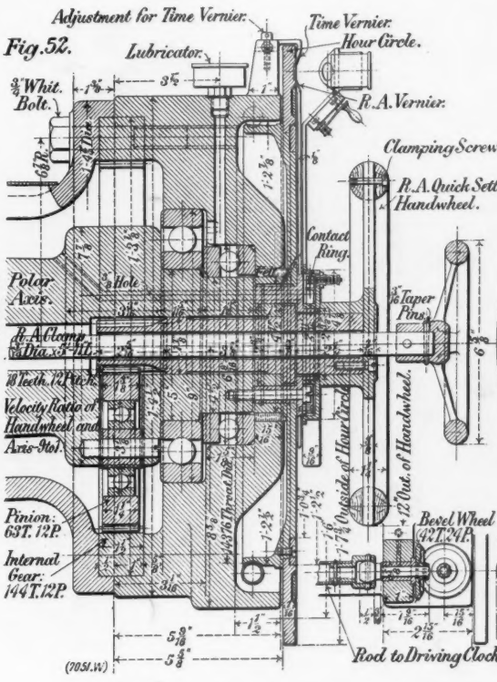


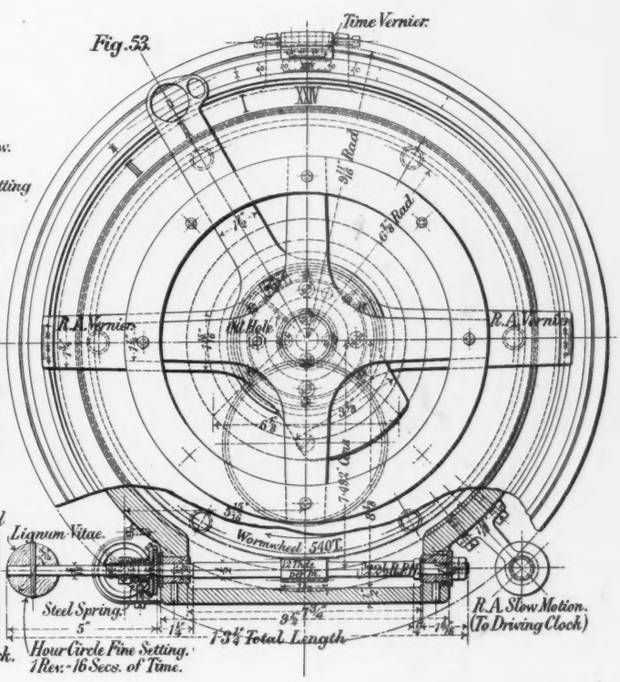
E NATIONAL OBSERVATORY, RIO DE JANEIRO.

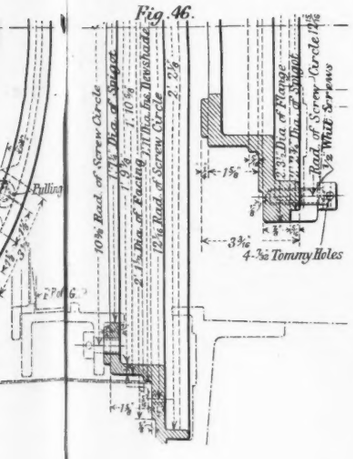
RS. T. CLARKE AND SONS, LIMITED, YORK.

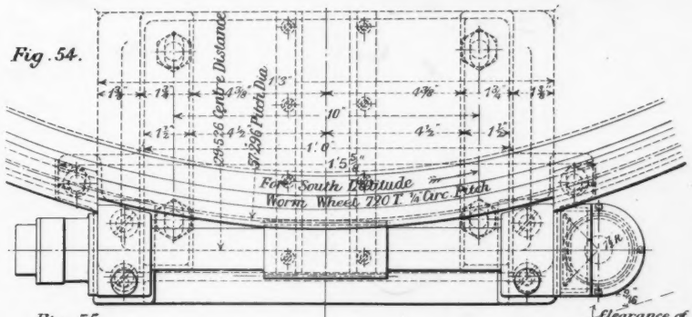
Description see Page 223.)

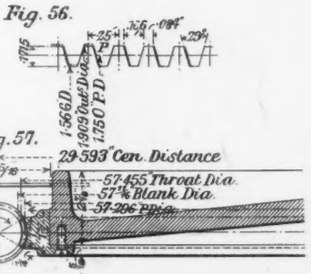












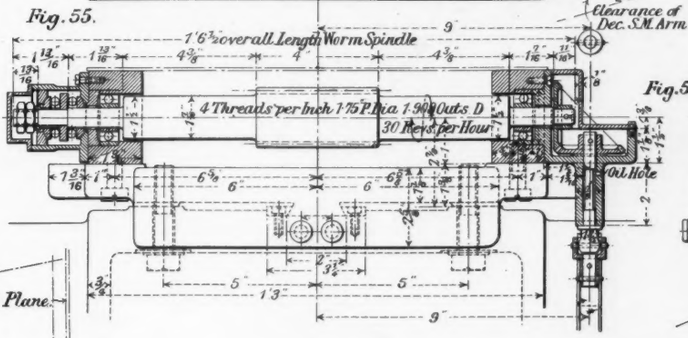
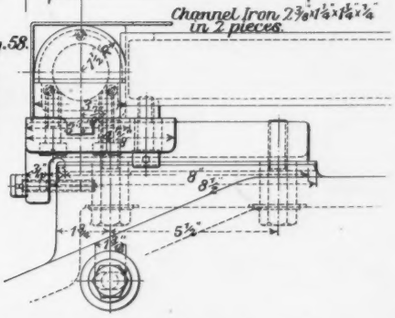
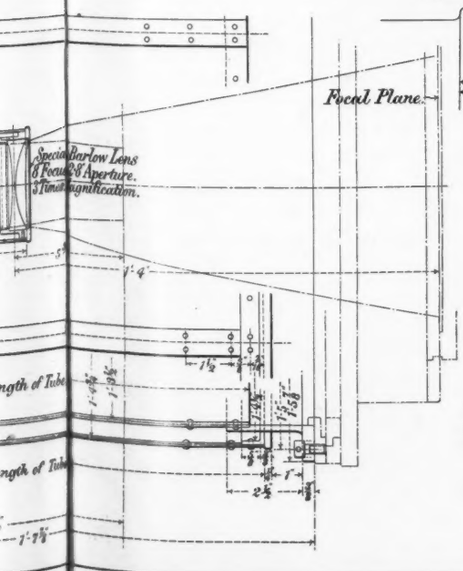


Fig.55.
1'6½ over all Length Worm Spindle
4 Threads per Inch 1.75 P. Dia 1.909 Outs. D
30 Revs per Hour
Oil Hole
Clearance of Dec. S.M. Arm





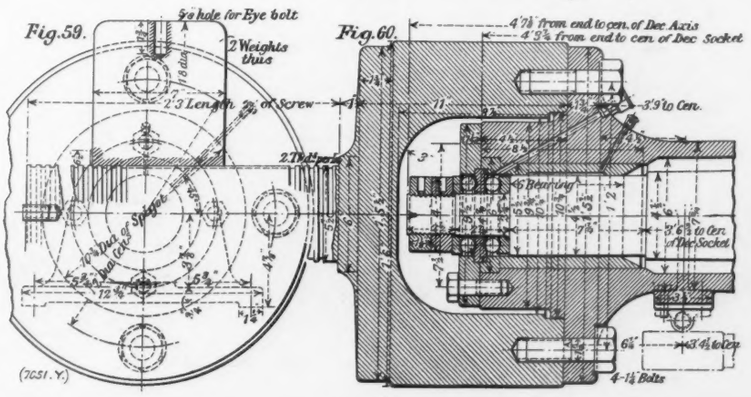


Fig.59.
⅝ hole for Eye bolt
2 Weights this
Fig.60.
4 7/8 from end to cen. of Dec Axis
4 5/8 from end to cen. of Dec Socket
3'9 to Cen.
4 Bearing
3'6 ½ to Cen. of Dec Socket
4-1½ Bolts

so, on what basis? Probably it could contract out if it could first of all settle its own boundaries; if the unskilled unions, of whose members some would be within the boundary and others outside, could be brought to agree, and if the practical difficulty of dealing with the numbers who migrate, or are believed to migrate, at different times and seasons from one industry to another, could be overcome.

If the engineering industry could contract out, is it desirable that it should do so, and what are the benefits to be obtained? The benefits to the workers would require to be increased, and the employers would require to dip their hands into their pockets, unless, as seems improbable, they could effect a corresponding saving in the cost of administration. It has been strongly urged that the industry cannot bear indefinitely the present high cost of production; that something must be done to bring it down; and that if there is any reasonable prospect of rendering the workers more contented and getting them to accept and "go full out" on payment by results, it would be worth while to risk the experiment of an unemployment insurance scheme for the industry. Against this there is the well-known argument that the causes of unemployment are to a great extent beyond the control of those engaged in industry, and that any willingness of the workers to do their best might count for little if, for any reason, the foreign markets for their products were closed for the time being. At the present time the National Insurance Fund is bankrupt; unemployment prevails to an unprecedented extent; the condition of affairs in Europe appears to be going from bad to worse, and while it is clearly desirable that the whole problem should be thoroughly examined, it is clear also that we cannot afford to leap before we look.

OIL PUMPING.

WHEN the Institution of Petroleum Technologists discussed the difficulties of oil pumping on the 13th inst., most speakers agreed with Mr. G. W. E. Gibson, who introduced the subject, that science had not yet solved all the problems which the peculiar properties of oils impose upon the pumping engineer. But Professor Hinchley seemed to consider that science had supplied, or could supply, the engineer with all the information required, certainly as to viscosity. The divergence was more apparent than real. Scientific research is not completed by laying down a formula. A formula cannot hold generally, and every step in a process has to be investigated. In the laboratory where viscosity and volatility constants are determined, oils are not tested under industrial conditions, and in industrial plants the stable conditions necessary for the determination of the friction of viscous oils in pipes can hardly be obtained over sufficient time periods without interfering with the commercial organisation. The only tests of practical value that Mr. Gibson knew of were made ten years ago by the Standard Oil Company with Californian crude oil. Even that wealthy company had found the task very difficult, Mr. Gibson remarked, and the results of the experiments had not been published. Fuel oils were becoming more and more viscous, moreover, so that the tables of a few years ago were almost valueless now. Mr. Gibson hoped to communicate the material he had himself collected to the Institution at a later date. In his present paper on "Some Practical Notes on Oil Pumping," he reviewed the main types of oil pumps which have found application, commenting upon designs and efficiency.

The suction main, Mr. Gibson emphasised in his introduction, required the utmost thought. With water a total actual suction lift of 26 ft. should never be exceeded. With a heavy fuel oil he had found the volumetric efficiency low even with vertical suction of only 10 ft. plus 50 ft. of horizontal suction pipe, though no trouble was experienced. There should be no right-angle bends or T-pieces in the suction main, which should be laid with a gradual rise towards the pump. All pockets in which gas could lodge should most carefully be avoided, and in any case the suction main should have as large a diameter as circumstances would permit. The diameter should, perhaps, not be less than 6 in.—in the case just mentioned the suction main diameter had been 4 in.—near the pipe well; the oil friction might be ten times and greater than the water friction would be. The forcing of the oil through the delivery pipe did not present particular difficulties, but pressures of 800 lb., and even 1,000 lb., per square inch were not unusual, and by increasing the size of the main enough fuel would be saved to justify the higher initial expense.

In his historical review of oil pumps Mr. Gibson first referred to single-cylinder pumps which the late Mr. Alfred Suart, one of the pioneers of the British oil industry, ordered in 1888 for the tanker Vindoba. This pump was a modification of the universal pump of Messrs. Hayward, Tyler and Co., which Mr. Suart fitted with an outside gear, by means of which the slide-valve could be thrown over by hand for starting. By 1890 Mr. Suart adopted duplex pumps of a size 10 in. by 10 in. by 12 in., still popular to-day. His pump had a removable gunmetal valve plate only for the suction valves, however, whilst in modern pumps both the suction and delivery valves are mounted on removable plates.

Mr. Gibson expressed a general preference for duplex steam pumps. They were more flexible than the more economical power-driven pumps and could be entrusted to unskilled attendance. The steam cylinders could be given ample dimensions to admit of a great variation in duty at low cost, whilst the maximum duty for which an electric motor had been chosen could not be exceeded. For delivery pressures above 250 lb. per square inch, he recommended duplex plunger pumps of the outside packed type, fitted with an alleviator and, on the s.s. San Fraterno, *e.g.*, with annular valves, spring controlled, working on gunmetal seats. These pumps, of 23½ in. by 8½ in. by 18 in., deliver 75 tons of thick oil per hour, against a pressure of 800 lb. Compound steam pumps of this type were often provided with Corliss valve gear which, very suitable in many cases, was impracticable for small pumps and unskilled attendance. For such conditions, *e.g.*, in the case of a duplex fuel-oil pressure pump, 5 in. by 3 in. by 8 in., Mr. Gibson's choice was the Twells patent valve motion, which, having a positive stroke, could never give trouble by short-stroking, and was very economical in steam consumption.

Power-driven pumps might be direct-driven or belt-driven. Oil men preferred the latter, though they took up more space. For important oil-pumping plants line shafting with a separate friction-coupling for each pump was probably most convenient. Mr. Gibson exemplified the various types by photographic views. The helical gearing of a duplex pump, with a crankshaft running at 45½ r.p.m., driven by an induction motor of 120 b.h.p. at 860 r.p.m., looked rather complicated, but Mr. Gibson had no time to enter into those particulars. The crankshaft of a horizontal treble barrel plunger pump, which Mr. Gibson had found to work smoothly at 49½ r.p.m., was also driven by a motor of 860 r.p.m. Of rotary pumps he showed a balanced turbo oil pump capable of delivering 180 tons of benzine per hour at 680 r.p.m. The casing of this pump was split horizontally, with a metal-to-metal joint without jointing material, a most important feature for that type of plant; the shaft of the pump passed through to a tube in the cofferdam. Further described was a rotary pressure pump arranged for belt-driving, to deal with thick crudes and fuel oils in the field, This pump was fitted with a separate set of driving gear wheels, driving by means of fluid rotors, which was deprecated in such cases.

One of the pumps of special kinds upon which Mr. Gibson commented was also of the horizontal treble-barrel piston type. It was designed for the Admiralty to deliver 300 tons of fuel oil per hour against 80 lb. per sq. in., or 100 tons against 150 lb. pressure, and was driven by a direct-current variable-speed motor to meet varying conditions. The second was a duplex pump designed to pump molasses, a material of a more troublesome viscosity even than oil. Very large passages and valve areas, with suction and delivery orifices of 14 in., had had to be adopted. The third pump, a duplex steam pump, of 10 in. by 10 in. by 12 in., had to deal with oil at a temperature of 752 deg. F. The valve boxes were made of a very close-grained cast iron, the ball valves of steel, and the pump could run for three weeks without a stop.

To minimise gas troubles, Mr. Gibson remarked in conclusion, oil pumps should, whenever possible, be of the horizontal type. When planning oil pump installations the probable temperature (average as well as extreme) and the altitude of the locality should, of course, be known, and information be given as to the grade, density and viscosity of the oil likely to be dealt with, the pumping temperature, the dimensions of the pipes and pipe line, and other features. The question of listed pump capacity was difficult. Sir Frederick Black had recently pointed out that viscosity meant little to the engineer on board ship, who would like to have actually pumping tests carried out at definite temperatures. Mr. Gibson conceded that such tests would be appreciated. In general, however, he stood up for the established custom of stating the capacity of oil pumps in tons or gallons of water per hour, because otherwise capacities would have to be given for every different grade and temperature. A reciprocating pump would have at least its water capacity for benzine, kerosene and thin oils, of lower viscosity than water, and such pumps might be run at from 40 to 60 double strokes per minute (or revolutions per minute), though for continuous long-period working half that speed was usually adopted. For heavy Mexican fuel and other oils, even when adequately heated, it was not prudent to assume more than two-thirds of the water capacity, and a speed of 30 double strokes could rarely be exceeded.

The paper covered a large ground. Being the first paper on oil pumping—apart from oil production—brought before the Institution, a time limit had to be put on the discussion. Most of Mr. Gibson's chief points, as to short and wide suction pipes, *e.g.*, were conceded by Mr. Barringer, Mr. Anfilogoff and the other speakers. But Mr. Anfilogoff pointed out that insistance on short suction pipes signified little in practice, when both the suction and the delivery had to be effected through pipe lengths of 3,000 ft. Mr. Anfilogoff also deprecated very strongly the use of belts in rooms where highly volatile oils and benzine of low flash-points were to be pumped; the danger of electric sparking was too great; he used countershafting in the rooms, admitting cords or belts only outside. Dr. Ormandy supported this warning, without convincing Mr. Gibson, who mentioned that belts had been adopted in recent oil-pumping plants. Dr. Ormandy also referred to the tendency, still stronger over here in certain buying departments than elsewhere perhaps, of keeping initial cost low. That accounted for the fact that some poor types of pumps managed to survive. With regard to the suction inlet diameter, Mr. Challoner alluded to remarks which Mr. R. W. Allen* made on inlet orifices recently in the Institution of Mechanical Engineers. Mr. Gibson concurred that this was a very important point, especially when materials of high viscosity had to be dealt with.

BRITISH TRADE WITH AUSTRALIA.

AUSTRALIA, a large food-producing country and a field offering enormous scope for development work, is at present in the anomalous position of having many thousands of her workpeople idle, when they could be at work and usefully employed but for the difficulty of wage rates. Such conditions must, before long, be rectified and labour be remunerated on economic terms, but in the meantime both employers and employees are suffering enormous losses and the industrial progress of the country is arrested. The true economic position has been to some extent obscured by the generous distribution of money in war gratuities, repatriation and war pensions, which amounted up to the end of June, 1922, to 117,500,000*l*. Until these schemes, apart from the service war pensions, are ended, a fall cannot be expected in the cost of living nor can a true view of the value of labour be obtained.

The staple agricultural industries are in a favourable position, except the meat export trade, which has recently suffered a collapse, but it is anticipated

* The remark was made during the discussion of Mr. Salmond's paper on the "Machinery of Floating Docks," ENGINEERING, November 25, 1921, page 720.

that recovery will take place when there are improved conditions in the overseas markets, as well as through the assistance provided under a Government subsidy scheme. The prices of all export produce have experienced a fall, with the single exception of merino wool, and a compensating expansion of business is essential to the maintenance of the favourable balance of trade necessary to meet the Australian overseas obligations which are estimated at 25,000,000*l.*

The miners are still in a very intractable mood and refuse any wage reductions or increased output, although the necessity for cheap fuel for manufacturing purposes must be apparent to all. The development of mining the brown coals in the Morwell district of Victoria is proceeding rapidly and the works for the power generating scheme are under construction. The town, which is springing up round the actual works, has been named Yallourn, and it is anticipated that the power-house there will be in operation in about two years' time. The cost of the complete scheme is estimated at 3,311,000*l.* Samples of the coal have been briquetted in Germany with satisfactory results and the Commission have placed an order for briquetting plant, consisting of four driers and five presses, with the Zeitz Company. The other contracts were mostly given to British concerns.

There are but few hydro-electric systems in Australia, but during the past year a large amount of work has been done in connection with the extension of the Tasmanian Government scheme of a total capacity of 58,000 h.p. The River Ouse has been diverted to the Great Lake, and a multiple-arch dam, 1,200 ft. long, has been constructed to increase the storage capacity. Many surveys have been made by the Government which show the possibilities of developing schemes which would provide over 250,000 h.p., apart from the present scheme at Waddamana.

A bonus of 50,000*l.* has been offered by the Government of Australia for the discovery of useful mineral oil, and although much work has been done, and the results justify further investigation, little or no oil has been recovered.

Mr. S. W. B. McGregor, H.M. Senior Trade Commissioner in the Commonwealth, recently presented a "Report on the Economic and Financial Situation of Australia," which has been published by the Department of Overseas Trade, and contains a wealth of information about British trade and prospects in this great market. Although trading relations have been re-established with Germany there is not yet much sign of activity because of the popular sentiment against the purchase of German-made articles. An Anti-dumping Act prevents injury to Australian and British interests. British trade in this market has steadily improved, but there is still a margin of 10 per cent. to 20 per cent. which could be diverted to the home country by greater attention to detail and to sales organisation. It is interesting to note that Australia became Britain's second best customer during last year. This field is a very attractive one for British goods because of the strong sentiments in favour of British products and trading systems, a generous preferential tariff, no exchange problem and a market which will grow with the success of the immigration schemes. The market is being attacked, however, by American and other traders and there may be keen competition in the future.

The weakness of the United Kingdom's position is in machinery, engineering and allied material. The import of manufactured iron and steel fell 20 per cent. in 1921–22 from the standard of 1920–21, but the total value of the material dropped 56 per cent. The British share in this market amounted in 1920–21 to about 64 per cent. There is room for improvement in the trade in wire where the United States of America holds the greatest part of the business, and in plates and sheets, where their share is considerable though less than that of the homeland. The closing down of the iron and steel works of the Broken Hill Proprietary Company, Limited, at Newcastle, N.S.W., was compelled by the conditions of employment of labour and the high cost of coal. This company normally employed in these works 5,880 men.

The figures for the importation of machinery and of other articles made of metal show a decided improvement in the proportions of the totals obtained from America, despite the adverse exchange and the Customs preference in favour of the United Kingdom. It is thought in Australia that the manufacturers in the United Kingdom are unable or unwilling to compete for Australia requirements in agricultural and dairying machinery. Sweden stands supreme in the supply of cream separators. In electrical machinery, Britain still holds the greater share in the market, but America is not far behind. It is thought that in this sphere the "service" of American concerns is producing a great increase in the magnitude of that country's trade. Ninety per cent. of the cable used in the Commonwealth is imported from this country. In the machine-tool markets British interests still account for 60 per cent. of the trade, compared with America's 37½ per cent. Mr. McGregor, in his interesting report, calls attention to the extraordinary success attending the opening by a British concern of show rooms in Sydney, in charge of an expert and suggests that this enterprise might be followed with advantage by other British firms. The motor car market is one which shows little satisfaction to those desirous of seeing British trade excelling. Only in the commercial vehicle section, which is a market not yet fully developed, do British products claim a reasonable share of the business. Roughly 30 per cent. of the cars imported are Fords. Britain can only attain to 7 per cent. of the total number of cars imported.

As a remedy for the congestion of passenger traffic in and around Sydney, it is proposed to electrify the suburban railways, to construct an underground railway and to build a harbour bridge. The preliminary work on the Underground railway was stopped owing to the war, but has now been resumed. A development of considerable interest in Melbourne is the proposed conversion of the cable tramways to electric traction at an estimated cost of 4,200,000*l.* Work is proceeding on irrigation schemes in many parts of the Commonwealth and other work is in contemplation. A great amount of detailed information and statistics are given in Mr. McGregor's report, the study of which will amply reward those interested in this market.

ATOMIC PROJECTILES AND THEIR PROPERTIES.

On Saturday last, at the Royal Institution, Professor Sir Ernest Rutherford, F.R.S., delivered the first of a course of six lectures on "Atomic Projectiles and Their Properties." It was, it will be remembered, by tracing the trajectories of such projectiles through matter that Professor Rutherford was able to show that the positive electricity in an atom was concentrated into an extremely small nucleus. Prior to this discovery the prevalent view was that the positive charge occupied a relatively large volume. This demonstration of the nuclear constitution of the atom has, as is well known, proved of fundamental importance in physics. It may further be recalled that with the aid of these atomic projectiles, Sir Ernest Rutherford appears to have succeeded in tapping the internal energy of atoms of aluminium, an event which quite conceivably may prove of primary import to the race.

In commencing his lecture Sir Ernest Rutherford said, that in the present course he proposed to give an account of the properties of swiftly-moving electrons and atoms, and of the effects produced by these in passing through matter. The study was not merely intrinsically interesting and important, but it had also played a notable part in modern developments of physics; having added very materially to our knowledge of atomic structure. This was due to the fact that these swiftly-moving particles afforded the best means of penetrating into the interior of an atom, and of searching out its inner structure and disclosing the magnitude and distribution of the forces which held the atom in equilibrium. Some questions, no doubt, were still obscure, and must be considered as *sub judice*.

In this first lecture he proposed to deal merely with the magnitude of the velocities which could be impressed on ordinary matter by various means, both terrestrial and astronomical. He would consider also the effects of impacts made at different speeds. Our conceptions of what occurred in collisions were inevitably coloured by our practical experience of the impacts of billiard balls and rifle bullets, and of the effects of shells. It would be interesting to see how far these concepts would prove of service when we considered the collision of bodies moving at very much higher speeds. In a sense we entered here into a new world, but nevertheless, it turned out, that with some modifications we could make use of our common experience, although the forces involved enormously transcended those of which we had had prior experience.

Let us consider, the speaker proceeded, the order of the velocities of which we had common experience on earth. A very fast aeroplane attained a speed of about ⅛ km. per second. A shell from a modern gun might move at about 1 km. per second, and the maximum rim speed of a turbine disc was somewhat less than one-half of this figure. In gases the molecules moved at very high speeds, the average

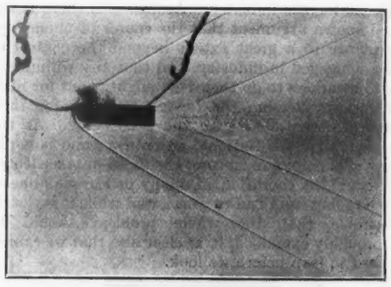


Fig. 1.

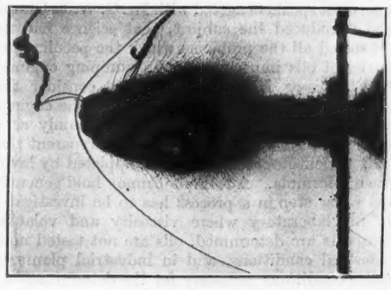


Fig. 2.

value of which was known with great precision. At 0 deg. C. the average velocity of a molecule of hydrogen was 1·84 km. per second, and this velocity increased in direct proportion to the square root of the absolute temperature, so that in a hydrogen arc speeds of five or six times the above figure might be attained. In the stars, however, temperatures of 2,730,000 deg. absolute were met with, and at such a temperature the hydrogen molecule would be dissociated and the resultant hydrogen atoms have a speed of 269 km. per second.

Coming next to the speed of large masses of matter, he believed that rather exaggerated ideas were prevalent as to the speeds attained in an unresisted fall from a great height. In the absence of the atmosphere a body falling to the earth from a height of 20 km. would have attained a speed of 0·6 km. per second at the surface, whilst if it fell from infinity under the attraction of the earth acting alone, the speed attained would be 11½ km. per second. Falling into the sun, however, under a similar hypothesis the speed attained would be 600 km. per second.

The energy associated with the motion, varied as the square of the velocity, and it was important to note how vast this energy was in the case of a body falling into the sun. Calculation showed that assuming all the energy was converted into heat and that the body had unit specific heat, the

temperature attained on impact would not merely suffice to cause the dissociation of the body into atoms, but to raise its temperature by some hundred millions of degrees. It was thus possible to gain some idea as to what would happen on the collision of two suns "end on," an event which it was supposed had taken place in some systems in space.

Coming next to the nature of collisions, Professor Rutherford took as a case which had been very thoroughly studied by the late Professor Worthington, the impact of a drop of a liquid with a liquid surface into which it was allowed to fall. Instantaneous photographs taken of the phenomena, showed that at an early stage a crater was formed in the surface of the liquid. This subsequently collapsed, and in doing so flung up again a drop, the material of which was the same as that of the original drop. A somewhat similar crater, the speaker continued, was formed on the front of a steel plate through which a shell was fired. In the

Fig. 3.

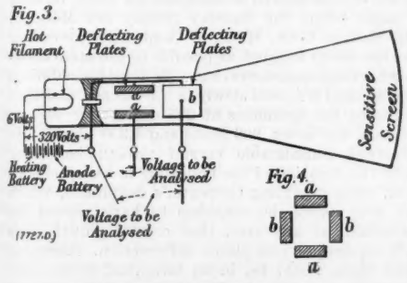


Fig. 4.

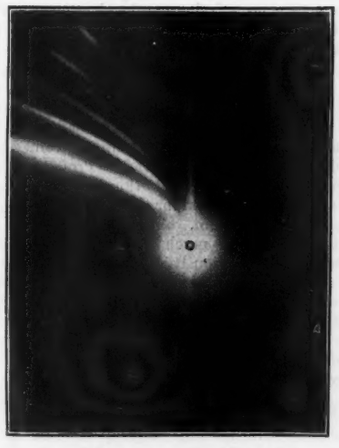


FIG. 5.

case of such impacts as were photographed by Worthington, the duration of the impact was of the order of $\frac{1}{5}$ of a second.

When two steel balls, hung pendulum fashion, side by side, were drawn apart and allowed to collide, the speed at the moment of impact would generally be of the order of from 11 ft. to 20 ft. per second and the duration of the impact was very much less than in the case of the drop. When the balls came into contact the surface was highly compressed, and forces of restitution came into play, causing the two colliding bodies to fly apart. The theory, to a first approximation, had been established by Hertz, and there was a reasonable accord between this theory and actual observation. The duration of the impact could, Sir Ernest proceeded, be determined by causing the balls when in contact to complete a circuit through a ballistic galvanometer. The swing imparted to the indicator of the galvanometer varied with the time of contact, and the arrangement could be calibrated by removing one of the "pendulums" and replacing it by a stream of mercury of definite thickness. A metal pointer attached to the remaining ball was arranged to pass through this jet of mercury as the ball swung pendulum fashion. The time of passage could be calculated, and a relation established between this and the throw of the galvanometer "needle." In this way it was found that the time occupied by the impact when two steel balls collided at moderate velocities was of the order of $\frac{1}{4000}$ second. This was, moreover, the less, the higher the speed before impact.

Many years ago, Professor Boys had studied the effect of the passage of a bullet through air and through various targets. By taking instantaneous photographs, Professor Boys had shown that when a bullet traversed air at a speed higher than that of sound, a pressure wave was generated at the nose of the bullet, as indicated in Fig. 1, whilst the air could also be seen in turbulent motion behind the base. In Fig. 2 the impact of the bullet with a sheet of glass was illustrated. Here the bullet carried along with it a whole mass of fragments of glass, but the air wave could be seen as before. In these cases the speed of collision was relatively low, but in the case of falling stars colliding with the earth's atmosphere much higher velocities were attained. Professor Lindemann and Mr. Dobson had made a careful study of the data available and had been able to arrive at some interesting conclusions. The meteors in question turned out to range in size from large shot up to about $1\frac{1}{4}$ in. in diameter. Much heavier ones fell occasionally. It had proved possible to form an approximate estimate of the velocity, height and distance of these small meteors. The height at which they were observed varied from 70 km. to 160 km. above the earth's surface, the average height being 80 km., whilst the average velocity was 40 km. per second, and the time of passage about 1 second. When such a small meteor entered the atmosphere a wave of compression was produced exactly as with a rifle bullet, so that the meteor surrounded itself with a cushion of air which by the adiabatic compression was raised to an extremely high temperature. The result was that the meteor was heated till it began to volatilise, and the molecules and atoms thus liberated, since they retained the velocity of the meteor itself, gave rise to the luminosity which was produced in this way and not by radiation from the molten mass. The molecules in question perhaps ionised the surrounding gas. The passage of the meteor was visible for about 1 second, but the afterglow occasionally persisted for some hours, and might thus be attributed to a recombination of the ions formed by the flying particles.

The highest speeds which had knowingly been generated on earth were obtained in the vacuum tube in which the electrons forming the cathode rays were accelerated by the electric field established between the electrodes. If one of these electrons fell freely through 1 volt of potential difference it would acquire a velocity of 595 km. per second. Since the velocity varied as the square root of the energy acquired by the fall, we should, if the electron fell through 100 volts, have it moving with a speed of 5,950 km. per second, and similarly for other voltages, though as the velocity approached that of light a correction was required since according to the doctrine of relativity the mass of the particle increased at very high speeds. Allowing for this, the velocity acquired by a fall through 10,000 volts would be 58,300 km. per second.

It was, however, sometimes convenient to have slow-moving cathode rays, and Sir Ernest Rutherford exhibited a new form of cathode ray tube which had been presented to the Cavendish Laboratory by the Western Electric Company.

This instrument is illustrated in Figs. 3 and 4. The electrons were, he said, liberated by heating a filament coated with certain oxides. This filament formed the cathode of the tube. The current required to heat the filament was produced by a 6-volt battery. These electrons were accelerated by establishing a potential difference of some 320 volts between the tube terminals. A certain small fraction of them were shot through the fine tube shown and passing between the deflecting plates indicated, ultimately struck the phosphorescent screen at the end of the tube. There were, it would be seen, two electric deflecting fields, arranged at right angles to each other as indicated in Fig. 4. Professor Rutherford showed that by causing a bar magnet pivoted at its neutral point to rotate near to the tube and in a plane parallel to the tube axis, the rays were deflected in such a way as to produce a circular ring of light on the phosphorescent screen, and, further, that if the deflecting plates were coupled up to an alternating voltage, the spot of light mapped out a sort of oscillogram on the screen, the base line of which was the circular ring obtained with the rotating magnet alone in operation. With these slow-moving rays a large deflection was obtained with a small difference of potential between the deflecting plates. This deflection was in fact about 1 mm. per volt.

The deflection experienced by a charged particle when it traversed a magnetic or an electric field could, Sir Ernest continued, be calculated from theory. Thus when the electrified body moved through a magnetic field its deflection A was inversely proportional to $\frac{m\,u}{e}$ where m denoted the mass of the particle, u its velocity and e the charge carried. Whilst in an electric field the deflection B was inversely proportional to $\frac{m\,u^2}{e}$. Hence, by measuring the two deflections A and B, we could determine both the velocity of motion and the value of the ratio $\frac{e}{m}$. We had, in fact, when the respective fields were suitably adjusted the relations

$$u = \frac{B}{A} \text{ and } \frac{e}{m} = \frac{A^2}{B}.$$

In the case of the electron it turned out that the ratio $\frac{e}{m}$ was $1{\cdot}77 \times 10^8$.

It was in this way that Sir J. J. Thomson originally determined these two quantities for the cathode ray discharge. In addition to the electrons which constituted this discharge, we also had in the tube positively-charged bodies, moving in the opposite directions. These were originally discovered by Goldstein and were known as the positive rays. Being much heavier than the electron, the mass of which was only $\frac{1}{1840}$ that of the hydrogen atom, these positive rays moved much more slowly than the cathode rays. Thus a hydrogen atom carrying one positive charge would acquire a velocity equal to but $\frac{1}{\sqrt{1840}}$ of that attained by an electron falling through the same voltage, but the energy it acquired would be the same. With 10,000 volts between the tube terminals positive rays of hydrogen might attain a speed of 1,400 km. per second. This speed would be acquired by an electron in falling through 5·5 volts. The mercury atom weighing about 200 times as much as that of hydrogen would in falling through 10,000 volts attain a speed of 100 km. per second, which the electron would acquire in a fall through 0·4 volts. The energy acquired, however, depended only on the voltage and the charge carried, and was the same for all atoms carrying a single charge.

The figures given above were maximum velocities, but in actual practice positive rays acquired very different velocities. When caused to pass through a fine hole in the cathode and subjected to the simultaneous action of electric and magnetic fields, the particles were deflected in such a way that they traced a series of parabolas on a fluorescent screen or photographic plate exposed to their impact. Each parabola was produced by particles of the same kind and carrying the same number of charges, but travelling at different velocities. In many cases, the positive particles carried more than one charge and Professor Rutherford exhibited Fig. 5, which represented, he said, a photograph taken by Sir J. J. Thomson, in which the positive rays were atoms of mercury carrying charges varying in number from 1 to 8.

NOTES.

THE GERMAN-BUILT U.S. AIRSHIP "CRUISER."

THE air cruiser which is being built for the United States Government by the Zeppelin Company at Friedrichshafen is approaching completion. In April she will be ready for trials, and during May she will cruise over Lake Constance and probably pass the Alps. In June it is hoped that she will proceed to Berlin, and will be fitted for her ocean flight at Staaken. The flying ground at Staaken lies 400 m. lower than Friedrichshafen, and the airship will have 5 per cent. greater useful load on departing from

that place. The American authorities desire that she shall fly direct from Berlin to Chicago without alighting, and she is expected to set out about the end of June. No statement has been made as to the command of the airship, but the technical direction of her will be in the hands of German airmen, engineers and mechanics. A large flying ground exists at Chicago, and a building is being erected to house the ship. There she is to make extensive trials, and upon their results a decision will be made as to the building of other airships of the type. In range and endurance the ship will exceed all her predecessors. It is anticipated that, when she has left Friedrichshafen, the Zeppelin Company will receive instructions to construct a like vessel for the ocean passenger air line intended to be inaugurated between Spain and South America. The scientific plans and practical preparations for this enterprise have been almost completed.

Vane Wheel Propulsion.

Many of the conditions imposed on the propulsion of ships by screw propellers operate against the attainment of high efficiency. After thorough investigation of these actions and endeavours to reduce their effects, Messrs. William Denny and Brothers, Limited, of Dumbarton, introduced what they term vane wheels. Readers of Engineering are familiar with this system of propulsion which was described in our columns (see vol. cxiii, page 822)—after a demonstration last June of its action as applied to an experimental boat of 100 ft. length. Mr. Maurice E. Denny has devoted himself, since his early research work, to the development of this propulsive device and presented a paper on the subject to the Institution of Engineers and Shipbuilders on February 13. The advantages possessed by vane wheels in the propulsion of shallow-draught vessels are: a reduction of slip through the use of large vane wheels rather than small screw propellers; free flow of water to the propelling agent; and the elimination of the large resistances caused by the dragging of the under-water shaft supports and the boss of a screw propeller through the water. In addition to the gain in efficiency, an accompanying improvement in manœuvring capabilities must not be lost sight of when discussing the use of vane wheels. The wheels may be robust and simple in construction, and if plate steel is used for the vanes, any deformation due to contact with heavy floating material may be repaired on the spot quite easily. The stern bearing, being above the water, may be efficiently lubricated and kept free from all sand and grit. The general arrangement at the after end of the vessel presents no features which are not already familiar to designers of stern wheel vessels. The dimension of the beam, the structural work at the outside of each wheel and the clearance allowed between them are the factors on which the diameter of the vane wheels is determined. As the size of the wheels is diminished the efficiency is reduced. The pressure per unit area of immersion seems to be the limiting factor for the minimum size. It is thought that turbulence and air drawing may be the cause of this action which is, at present, the subject of investigation. In order to obtain full advantage of the high efficiency of the system, the vane wheels must be of as large a diameter as possible.

The Endowment of Research.

Although this country has contributed its share, and more than its share, to scientific discovery and invention, it is quite frequently said that the value of research is not appreciated here to the extent that it is elsewhere. At one time there was probably some truth in this, but the charge at all times had to be levelled against the general public and our governing authorities, and not against our scientific men. It is, however, doubtful if there is now much truth in the idea even when directed at the most non-technical circles, and the activities of the Department of Scientific and Industrial Research and of the National Physical Laboratory are probably generally appreciated even where they are not understood. In research work undertaken by individual manufacturing firms with the deliberate idea of benefiting their manufacturing methods and improving their products, we still lag behind America, although considerable and important developments are now taking place, but it is doubtful if this field of applied research is more adequately covered in any part of the world than it is by the numerous research associations allied to the Department of Scientific and Industrial Research. It is in the field of pure research that the greatest lack of means now exists and Sir Alfred Yarrow, by his magnificent gift of 100,000*l.*, has enormously added to the prospects and possibilities of work of this kind in this country. The fact that Sir Alfred has made this gift to the Royal Society is a remarkable tribute from a successful practical engineer and business man to the value of pure research. He has made no conditions about its use, but has expressed a wish that it shall be used to aid scientific workers and purchase apparatus rather than be spent on bricks and mortar. That the Royal Society will respect this wish of their distinguished member there can be no more doubt than there can about its wisdom. Sir Alfred by his gift of the experimental tank for ship model work to the National Physical Laboratory, had already established a deep claim to the gratitude of all those who have the scientific and industrial advance of this country at heart, and by his latest gift has made adequate acknowledgment almost impossible.

The American Tariff.

An article in *The Iron Age*, New York, refers to "the flexible provisions of the Fordney-McCumber-Tariff Act," which embody a plan devised, as a result of insistence on the part of President Harding himself, for reducing or increasing duties on imports, and generally accepted, we are told, as affording a basis for scientific tariff-making. "Within certain limits and under certain conditions," duties can thus be adjusted to changing economic conditions throughout the world. As an instance of the difficulty "in applying the flexible provisions in their entirety," our contemporary refers to the recent refusal of French manufacturers to divulge the cost of production of French goods exported to the United States, and competing with American goods. Some time ago, the United States Tariff Commission sent two agents to Europe, to obtain from France, Belgium and Switzerland, preliminary data to be used in the adjustment of tariff rates. We are told that they had hardly begun work in France, when they were met with one refusal after another with regard to French production costs, and it was indicated that the attitude of French manufacturers might be followed by those in other countries, on the general ground that the diversity of conditions was such that investigations of this character could not give results of practical utility. On the other hand, the Tariff Act, it is further stated, embodies "stern provisions of retaliatory character," by which imports from countries whence information is desired, could actually be prohibited. The situation is complicated rather to the detriment of foreign countries, by the fact that since the Commission has only 150,000 dols. to carry on the work until the end of the fiscal year, June 30 next, the investigations cannot be elaborate. Congress has voted 700,000 dols. (instead of the 1,000,000 dols. asked for) to last the Commission down to the year ending June 30, 1924. The plan in question seems to be an extremely curious one, and it is hardly surprising that foreign manufacturers should be unwilling to co-operate in it. American tariffs have always been set up to afford protection to American industries, the protection of the home industries being the final object of any protective tariff. Does this plan mean that American industries would receive less protection if the Commission found that the cost of production abroad of articles destined for importation into the United States exceeded a certain established limit? Are freight charges to be taken into account? A low freight might balance an increase in production cost. The "stern retaliatory measures" referred to are not altogether a pleasant feature of the plan.

Crystal Growth in Cadmium.

It is generally agreed that the degree of plastic deformation which a metal has undergone has a decided influence on the resulting grain size and on the temperature at which the recrystallisation sets in, both grain size and temperature of recrystallisation being lowered as the stress increases. Beyond that there is not much agreement. While many workers use the terms crystal growth and recrystallisation indiscriminately, Professor H. C. H. Carpenter and Mr. C. F. Elam draw a sharp distinction. By recrystallisation they understand a complete re-orientation of the crystals starting from new centres and leading to a refined structure, whilst by crystal growth they mean the rearrangement of certain crystals in a crystal aggregate to conform with the orientation of certain other crystals, the latter increasing in size by the addition of re-orientated metal. Neither processes, they maintain, can take place without previous deformation. In order to avoid the deformation which in preparing microscopic specimens would be produced by the polishing operations, the fused metal is sometimes poured on polished steel or on plate glass. It is doubtful whether strains can be excluded by that method, and it may indeed be questioned whether this is at all possible. In his investigation of the crystal growth of cadmium, on which he read a paper before the Faraday Society last Monday, Mr. Maurice Cook, M.Sc., of Cambridge, submitted the specimens as much as possible to the same treatment, except as to annealing. He fused his cadmium and allowed it to cool slowly in the furnace, and then annealed the specimens at 295 deg. C. for various periods, 450 hours, 900 hours and 1,350 hours. He observed considerable crystal growth increasing with the duration of the annealing in his specimens and, while accepting Carpenter's definitions, which we gave above, he considers to have proved for cadmium, at any rate, that crystal growth does not require previous plastic deformation. Assuming that there would be, in an unworked metal, considerable variation in the shape and size of the grains, crystal growth should take place on annealing. Mr. Cook rejected Tammann's view that non-metallic films on the boundary faces as a rule prevented the union of the grains to large crystals. Pointing to Fraenkel's experiments, which last year failed to disclose crystal growth in gold heated above 1,000 deg. C., he suggested that there had really been crystal growth in this case of pure unstrained gold, in spite of Fraenkel's assertion. Professor C. H. Desch, who sent in a contribution to the discussion, suggested an explanation for the different behaviours of gold and cadmium. A cubic metal like gold might cool without much internal stress, the co-efficients of contraction being the same in all directions; in the less symmetrical crystals of cadmium the unequal contractions in different directions might set up internal stresses of the same order as those due to cold-working. Dr. Desch also criticised Tammann's views: but the whole subject is very controversial.

New Rudder for the R.M.S. "Aquitania."

An interesting piece of ship repair work has just been completed at Southampton in fitting the Cunard liner Aquitania with what is practically a new rudder. The rudder, which is of the balanced type, and is supported on a single steel pintle, 16 in. in diameter, is a hollow steel casting, made in three sections with horizontal flanged joints; its fore and aft length is 28 ft., its depth 23 ft., and its total weight about 80 tons. When the ship was dry docked for her general winter overhaul on December 12 last, it was found that part of the flange between the upper and central sections on the port side, near the pintle, had cracked through, though the defect had not been previously suspected, and its cause was unknown. It was, of course, necessary to replace the damaged parts, and the work of dismantling the rudder was commenced two days later by the repair department of Messrs. J. I. Thornycroft and Co., Limited. The central section was despatched to the works of the Darlington Forge, Limited, the makers of the rudder, on December 17, and the upper and lower sections followed on December 19. The stock left Southampton on December 28, and the vessel was floated out of the dock on December 31. The original patterns having been destroyed, new patterns had to be made for casting the upper and central sections, but the castings, weighing 27 tons and 22 tons, respectively, were made, machined, lined up, and finally inspected at the works of the Darlington Forge by the 11th inst. This work, it should be mentioned, included re-facing the stock and making

a new pintle, but the original casting of the lower section was re-used, having been sent to Darlington for fitting purposes only. The vessel re-entered the dry dock for shipping the new rudder on the 13th inst., the work being commenced immediately on the arrival of the rudder stock from Darlington on the following day. The remaining parts reached Southampton on the 16th inst., and the sections were all permanently bolted together by Monday morning of this week. The pintle was replaced, and the whole repair completed in the early hours of Wednesday, the working of the rudder being tested to the satisfaction of the officials of the Cunard Company, the Board of Trade and the underwriters during the forenoon of that day. The whole performance certainly reflects great credit on all concerned. During the present overhaul, a new dummy has been fitted to the port high-pressure turbine, but only very minor repairs were needed by the other turbines, and no repairs were required by the boilers. The Aquitania, we may add, was built by Messrs. John Brown and Co., Limited, of Clydebank, and was first put into service in 1914. She was fully described in ENGINEERING, vol. xcvii, on pages 619, 655, 678, 693 and 727. Throughout the war period, and for some time afterwards, she was employed on Government service, and on the completion of this work was re-conditioned and fitted for burning oil fuel. From the early summer of 1920 until December last she has been in continuous service on the Atlantic route, and she will resume her sailings on March 10 next. Together with the Berengaria and Mauretania, the Aquitania will enable the Cunard Company to maintain a weekly service of fast passenger liners between Southampton and New York.

THE LATE MR. ADAM SCOTT.

WE regret to have to record the death, which occurred in London, on the 13th inst., of Mr. Adam Scott, a well-known engineer and member of the Institution of Civil Engineers.

Mr. Scott was born on January 1, 1855. On leaving school he became pupil, and later assistant, to Mr. J. W. Sandeman, on the Weaver Navigation. In the course of his career he carried out a large amount of harbour work on the Clyde, the Tyne, the Thames, at Gibraltar, also in Brazil, Chile and China. In the 'nineties of last century he took up an appointment under the Admiralty as Superintendent Engineer in charge of the new harbour works and dockyard at Gibraltar, an undertaking which was commenced in 1893 and was completed in 1906. The work was of very great magnitude; it involved the construction of three large breakwaters, dredging and blasting for deepening the harbour, three dry-docks, reclamation work, the building of retaining walls, tunnel construction, &c.

On completing this, Mr. Scott was appointed Technical Adviser and Engineering Chief to the Chilean Government for Port Works in 1907, when he reported upon the principal ports of Chile, and four years later submitted to the Chilean Government authorities detailed estimates for proposed improvements at the main ports of that country. He went to Brazil a first time for the survey of Brazilian ports in 1883, and returned there in 1919 to investigate and report upon the proposed improvements to the port of Parahyba. During the past year or so, he had been engaged in completing working drawings and specifications for a comprehensive scheme in connection with large harbour extensions in China.

Mr. Scott read a paper before the Institution of Civil Engineers in 1894, on "Deep-Water Quays, Newcastle-upon-Tyne," for which he was awarded a Telford Premium in 1895. He read before the same Institution, in 1914, a paper on "New Harbour Works and Dockyard, Gibraltar." He was a civil engineer of high standing, and, like all really competent men, was most unassuming, caring far more for the good name of his profession, which he so highly esteemed, than for any purely personal recognition.

LLOYD'S REGISTER OF SHIPPING.—We have received from this society a copy of a reprint, in pamphlet form, of a lecture by Mr. F. A. Mayne, giving a detailed explanation of the terms and data used in the Society's Register Book of Shipping. The lecture was delivered at Gresham College on November 28 and December 11 last, in connection with the marine insurance classes organised by the Institute of London Underwriters, and a careful study of the pamphlet should do much to enable users of the Register to obtain the maximum of information from its contents. Mr. Mayne, we may add, is assistant to Mr. Andrew Scott, the secretary of Lloyd's Register, so that he is fully qualified to deal with the subject.

NOTES ON NEW BOOKS.

WHEN a laboratory staff devotes its attention to the prosecution of a series of inquiries all connected with an important branch of industry, considerable interest may well be taken in a series of brief extracts showing the methods of investigation employed and the results attained. On this ground, we welcome the appearance of the "*Abstract Bulletin of Nela Research Laboratory National Lamp Works*," No. 3, Cleveland, Ohio (published by the Research Department), and congratulate the staff on the amount of work achieved. No less than 36 papers are summarised in this volume, which cover a number of important problems, mainly connected with the behaviour of illuminants and with aspects of the theory of radiation. But we venture to suggest to the management that the value of this collection would be greatly enhanced, if the publication of these extracts was made with greater frequency. Some of the abstracts refer to original communications that appeared as far back as 1915, and none, we think, of later date than 1918. It is announced that the departments of pure and applied science are now conducted in separate laboratories, Dr. E. F. Nichols being the director of the pure science section, and Mr. M. Luckeish of the laboratory of applied science. This division, while extending the usefulness, might also accelerate the publication of results. As often a preliminary note has been published in some journal followed by a complete paper in another, this plan might be extended, and a postscript added giving the result of further experiments in which the observations have been repeated, under similar or varied conditions. The results of some of the practical applications after trial might prove interesting. For instance, an informing account is given of the method adopted for lighting the Cleveland Museum of Art, by E. P. Hyde, the Director of the Laboratory. The communication describes an experiment on a large scale, in which the suggestions of skilled engineers were put into operation to secure certain effects, by plans specially devised to meet the difficulties encountered in illuminating picture galleries, courts of tapestry and armour, garden courts, &c. It would have been instructive to know how far the plans, which are somewhat elaborate, met with public approbation, and comparison of costs with other systems of illumination would have been of assistance when deciding on alternative designs. An interesting experiment has been carried out, but its details need not be limited to the laboratory, and many are interested in the result. Some of the investigations seem to have been arrested at an early date, as that into the Catalase content of Luminous and non-Luminous Insects, by Mr. Burge, and others have probably been repeated, as that on the Thermal Expansion of Tungsten at Incandescent Temperatures, by Mr. Worthing.

The advantage to be secured by the wider use of a smokeless fuel such as coke have been frequently placed before the public, which, however, does not pay very much heed to the matter. Addressed to another class, a little pamphlet written by Mr. G. M. Gill, will perhaps have better fortune than the ordinary propaganda. This pamphlet is entitled "*Coke for Steam-Raising Purposes*" (Walter King, Limited, London; price 1*s.* 6*d.* post free). It is addressed to gas works' engineers and managers, and its object is to encourage the sale of coke instead of controlling the market by using this fuel for the manufacture of water gas to be mixed with the coal. The little work discusses the conditions under which coke can be successfully used, and makes many commonsense suggestions with regard to assisting and advising clients in changing over to coke, instead of expecting good results to follow upon merely dumping a load in their store. The coke considered by the author is the ordinary product, and there is no suggestion so far as we can see that its quality might be made more attractive by modification of the gas-making process.

The development of heavy oil engines has been carried out so rapidly that comparatively few marine engineers have, so far, had extended experience of their running, and there has consequently not been much opportunity for the preparation of books on actual experiences with these engines or their reliability at sea. Marine engineers have always taken great interest in these matters, and for steam-driven plant have produced some valuable literature. The Council of the Institute of Marine Engineers, recognising the scarcity of general knowledge or experience with oil engines, wisely decided to remedy the deficiency by inviting a number of their members to contribute papers on sections of the subject. These concerned, not only the installation and running of the different types of internal-combustion engines, air and solid-injection for Diesel engines, lubrication, auxiliary machinery for oil-engined vessels, and the discussion of constructional details of the plant, but also the available supplies of fuel, their properties and the testing operations necessary to determine their characteristics. In all 18 papers were contributed, and although there was much overlapping and also a considerable amount of diversity of opinion among the authors, the Institute is to be congratulated on its efforts and the results obtained. The lectures have now been reprinted and published by the Institute as a volume entitled "*Papers on Internal-Combustion Engines*," at a price of 12*s.* 6*d.* This forms a good supplement to the present literature, which is mostly concerned with the theory and design of the different types of this class of prime mover.

The study of the subject of construction costs is apt to become a little wearisome to those who are not practically interested, and when an author finds some 1,700 pages necessary to convey the information he has collected, one may admire his industry, his method of systematising his abundant material, and his skill in arranging his facts, but decline to enter into details. In the example before us, "*A Handbook of Construction Cost*," by H. P. Gillette (McGraw-Hill Book Company; price 30*s.* net), the difficulties of grasping the scheme are rendered the more severe as the present collection of data is intimately connected with an earlier work, published twelve years ago entitled, "*The Handbook of Cost Data*," itself 1,800 pages in length. The alternative presented itself to the author of either revising that work or of producing an entirely new book, and he chose the latter, because he contends that the data provided there are by no means out of date, but can be made applicable to modern undertakings. The method recommended is based on the conviction that unit costs can be determined and presented in such a way as to serve for a century or more, provided the methods of construction do not change. If the number of hours of labour of each class, and the details of the units of materials are given with sufficient accuracy for any one date, then it is claimed the cost of construction at any other date will be known by multiplying the old costs by the ratio of the present rates of wages and of prices of materials to those obtaining at the earlier date. In this way, the effect of the rise in prices of labour and of materials, even in a disturbance so momentous as that occasioned by the World War, can be allowed for, and the old data be made to serve as a guide for other estimates. The author derives equations, whose solution furnishes an index price for both materials and for wages, which, he declares, represent the available statistical facts "for so many years as to leave no doubt as to their substantial accuracy." It is impossible to discuss here whether all the factors of the problem have been taken into account, or whether the data can be obtained with a close degree of approximation, but the form of the equation is very simple. The one used for commodity prices may serve as an example. It states that, the average price is equal to the product of one-half of the money spent and the "Velocity of circulation," divided by the products of the number of the population and the *per capita* efficiency of production. Many curves are given which show that the actual wholesale index price coincides very closely with that calculated from the formula. Several of these curves might have been drawn on a larger scale with advantage. Possibly it is more important to note, that Mr. Gillette is the editor of *Engineering and Contracting*, and that in this capacity he has had access to the detailed statements of many contracts in every branch of engineering, civil, sanitary, railway and marine, and that he has used this information wisely and exhaustively. He not only gives prices, but discusses the consequences of following alternative methods in construction, and traces the conditions under which it may prove desirable to change from one method to another. He is not a believer in the maxim that "modern progress is so rapid that costs data, ten years old, are inapplicable," but is confident that the experience of the past deserves the closest examination. In constructing an estimate it is of assistance to know the cost of similar operations under like conditions. In this spirit, he has compiled this storehouse of information, whose merits will be known only to those who are prepared to give to its varied contents both time and determined study.

"HYDRO-ELECTRIC ENGINEERING," ERRATUM.—In the review of "Hydro-Electric Engineering, vol. ii," which appeared in our last issue, on page 193, in the third line from the beginning of the article, for "1891" read "1921."

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS (INCORPORATED).—At the annual general meeting on the 14th inst., the following officers were elected: President: Mr. R. J. Insell, chief assistant signal engineer, G.W.R., Reading. Vice-President: Mr. W. J. Thorrowgood, signal and telegraph superintendent, S.R., S.W. Section, Wimbledon. Hon. Treasurer: Mr. A. E. Tattersall, signal superintendent, L. and N.E.R., King's Cross Station. Hon. Secretary: Mr. M. G. Tweedie, signal department, G.W.R., Reading.

THE TORSION OF SOLID AND HOLLOW PRISMS AND CYLINDERS.

To the Editor of Engineering.

SIR,—In a paper contributed to ENGINEERING, vol. cii, pages 497 and 521, November 24 and December 1, 1916, on the "Torsion of Solid and Hollow Prisms and Cylinders," I included, among some miscellaneous examples, an approximate formula

$$\theta = \frac{\phi^2 \, T \, l}{3 \, G \, A^2 \, t_1^2} \left[A_1 + \frac{t_1^2}{t_2^2} A_2 \right] \quad . \quad (1)$$

for the angle of twist θ, of an I-beam having a web of cross-section A_1 and thickness t_1, and flanges of total cross-section A_2 and thickness t_2, under a twisting moment T. (Equation 25, §6.)

I have recently received a letter from Mr. T. H. Jones, of the Manchester College of Technology, pointing out that this formula does not agree with that derived from the method given by Dr. Prescott (*Phil. Mag.*, November, 1920). This method is based on the assumption that the angle of twist in each flange is the same as that in the web, and leads to

$$\theta = \frac{\phi^2 \, T \, l}{3 \, G \, (A_1 \, t_1^2 + A_2 \, t_2^2)} \quad . \quad . \quad (2)$$

I find that the formula (2) is correct and is the one I should have arrived at from an application of the method given in §5 of my paper. My error was due to assuming that the maximum stress occurred in the thinner part of the section. The reverse is correct, as may be seen at once from Taylor and Griffiths' soap-film analogy.

The proof of (2), by my method, is as follows: Consider a thin strip A C made up of two parts, A B of thickness t_1 and cross-section A_1 and B C of thickness t_2 and cross-section A_2. Then

$$f = c \, x^2 + d,$$

using the notation of my paper. It follows that

$$f_{AB} = c \left(x^2 - \frac{t_1^2}{4} \right), \; f_{BC} = c \left(x^2 - \frac{t_2^2}{4} \right)$$

and

$$T = \frac{K \, c}{3} (A_1 \, t_1^2 + A_2 \, t_2^2).$$

This leads to

$$q_1 = q_2 = \frac{3 \, T}{A_1 \, t_1^2 + A_2 \, t_2^2} \cdot 2 \, x.$$

Thus $\frac{(q_1)_{max.}}{(q_2)_{max.}} = \frac{t_1}{t_2}$, and the maximum shear is in the thicker part of the section. Also

$$\theta = \frac{l}{T \, G} \int q^2 \, d \, a = \frac{9 \, T \, l}{3 \, G \, (A_1 \, t_1^2 + A_2 \, t_2^2)}$$

This agrees with (2) if $\phi = 3$ (*c.f.* §6). The extension to a strip having several parts of different thicknesses is obvious.

I remain, yours sincerely.

CYRIL BATHO.

Department of Civil Engineering and Applied Mechanics, McGill University, Montreal, February 9, 1923.

MODERN TURBINE EFFICIENCIES.

To the Editor of Engineering.

SIR,—I am interested to notice an article in the pages of ENGINEERING setting forth the results of an independent test on a 5,000-kw. Brush-Ljungström turbo-alternator installed at the Birchills power-station of the Walsall Corporation.

The results quoted reflect credit on the Brush Electrical Engineering Company, as an "overall thermodynamic efficiency" of 76·4 per cent. was obtained during the test, and although the data given is insufficient to enable one to go very fully into the figures, it appears that the efficiency ratio on the Rankine cycle is in the region of 77 per cent. at full load.

In the absence of complete data for the trial, this figure appears to be excellent, but I think it is only fair to the original designer and constructor of this type of turbine, Mr. Berger Ljungström, of Sweden, to point out that the first or experimental machine of only 1,000-kw. capacity, built about nine years ago, actually realised, I believe, an efficiency ratio of about 72 per cent., whilst his first 5,000-kw. set, built some six years ago, gave an efficiency ratio of approximately 77·2 per cent.

It is unfortunate that difficulty is generally experienced in obtaining the complete data for steam turbine trials, but up to the present time both the published and the unpublished figures for turbines up to 5,000 kw. denote that the double-rotational radial flow Ljungström machine appears to possess a higher efficiency ratio than that of other types.

The large 40,000-kw. sets commissioned last year at the Gennevilliers Works, near Paris, have a calculated efficiency ratio of approximately 76 per cent., whilst the 18,750-kw. turbo-alternators at Dalmarnock, in Glasgow, have apparently an efficiency ratio of about 75 per cent., although precise data for both of these modern power-houses has not yet been published.

Efficiency ratio on the Rankine cycle is by no means, of course, the only criterion of the commercial performance of steam turbine plant, as reliability and maintenance costs are undoubtedly of immense importance in the development of cheap and satisfactory supplies of electrical energy by means of large units of generating plant.

In this connection it is interesting to note that the 20,000-kw. Parsons' set supplied to Chicago about nine years ago has proved to be a good example of both reliability and efficiency, the efficiency ratio being as high as 77·4 per cent., whilst simplicity (which used to be the hallmark of good design) was not in any way sacrificed.

Further progress in turbine design and efficiency is no doubt largely governed by metallurgical considerations, but until manufacturers and others allow complete test data a certain amount of publicity, both in text books and technical journals, our progress will be all the slower, and impartial engineers will still have difficulty in accurately gauging for themselves any real improvements in efficiency over a period of say, five or six years, as I have indicated above.

Yours faithfully,

L. MARSHALL JOCKEL.

46, Jesmond-avenue, Wembley, Middlesex, February 17, 1923.

"RAINFALL AND FLOOD."

To the Editor of Engineering.

SIR,—I noticed in your issue of November 17, 1922 (page 614) an article on "Rainfall and Floods" which interested me greatly, as I have spent much time and thought on the solution of the problem there under consideration. One point, however, I particularly noted, and cannot allow to pass by unchallenged. An equation is given for the calculation of flood flows derived from the general formula,

$$q = \frac{p \, . \, d \, A \, . \int_0^{t_1} I_t \, d \, t.}{t_1}$$

Now my contention is that the above general formula is fundamentally wrong, for the following reason. If I_t is treated as a variable dependent on the position of d A and on the time taken by a particle of rain, falling on d A, to reach the outlet, it is obvious that the final formula will show the run-off based on the supposition that the rainfall is not constant in intensity over the whole area at any instant, but that this intensity is varying from outlet to source of stream according to some mathematical law.

I do not know of any facts, or observations, which prove, or purport to prove, this to be the case, and only once before have I seen this theory advanced. This may be found in vol. i of "American Sewerage Practice," pages 292 and 293, where it is attributed to Carl H. Nordell, and where, after a short discussion, the authors, Messrs. Metcalf and Eddy, conclude that the assumption of a constantly-changing rainfall is erroneous.

Generally, when the method outlined in ENGINEERING is applied to the solution of "flood flows," an average intensity of rainfall is used, varying inversely as some power of t, but constant over the whole drainage area under consideration. This method, known as the "rational method" of determining flood discharges, has been used by me for some time past with every success.

For fuller information on the subject I must refer anyone interested to a letter of mine which appeared in *Engineering News-Record* for September 28, 1922, where, besides a formula, I have evolved for computing intensities of rainfall applicable to any region, formulæ are given, based on Dun's drainage tables, for the calculation of bridge and culvert waterways.

Yours sincerely,

GEORGE RIBEIRO,

B.A.(Cantab.), Assoc.M.Am.Soc.C.E.

Leopoldina Railway Company, Rio de Janeiro, Brazil, January 25, 1923.

MARINE REDUCTION GEARING.

To the Editor of Engineering.

SIR,—I have read with great interest articles in ENGINEERING of April 7 and 14, 1922 (pages 438, 467 and 469), by Messrs. Smith and Wilkie, and of December 29 (page 815), by Messrs. Thorne and Calderwood, on marine gearing. The experience of the Westinghouse Electric and Manufacturing Company may throw some valuable light on the question. The earlier article takes the view that the difficulties are much greater with double-reduction gears because there are more critical speeds. We had one design used on a number of ships, and if the term "roarer" could be rightly applied to any boat it was certainly applicable in this case. At full speed for 4 hours the *personnel* was so affected that after a night's sleep the roar still remained in their heads, and it was the general opinion that continuous service would mean insanity.

This was a single-reduction set. The words of Dr. Smith applied exactly. At a low speed a rumble commenced which *gradually* increased as the speed increased to a loud roar. The construction we use involves a flexible shaft of more than usual flexibility. Our investigations of teeth showed errors of the order of one mil, and at first we hunted for critical speeds, but the word "gradually" in the above paragraph convinced us that this was not the cause. We went back to the examination of the gears and found that though the errors were very small, they recurred periodically. When we altered out gear hobbers to reduce the amount of this error and reduced the pitch of the error, the roar disappeared. This experience inclines us to the belief that it was the increased flexibility on the Melmore Head that permitted the pinions to vary slightly in their instantaneous velocity without the same variations in the great mass of the turbine spindles, that made the job right. We believe that if the flywheel had been omitted the results would have been even better. In all our experience caused by critical speeds we never found a case where effect *gradually* increased through any great range of speed.

We believe Mr. Smith is wrong in assuming so many harmonics. Actual tests have shown that propellers have sometimes a first harmonic, but practically nothing higher. Also, higher harmonics, due to poor gear cutting, while present are usually small. In Messrs. Thorne and Calderwood's article they state that "A dangerous condition may occur if the node falls in either train of gears." This does not occur in most cases because the critical speed is higher than maximum propeller speed.

We have two ships running, in one of which the node falls almost exactly in the main gear, but it is the most successful job we have. We believe the success is due partly to good gear-cutting and partly to flexible shafts. The other ship has a node that does not fall in the main gear, and it has not been quite as successful. We believe this is due to the fact that you cannot make a fiddle vibrate in nodes by fiddling at the node point. A nodal point is one where there is no vibratory motion, and it is impossible to transmit much vibratory energy such as from a propeller to a critical system if it is applied at a node, because energy is a product of force and motion.

Yours very truly,

WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY,

A. T. KASLEY,

Head of Research Department, South Philadelphia Works, Lester Sub-Station, Philadelphia, Pa.

January 26, 1923.

"SUGGESTED SPECIFICATION FOR PERMANENT MAGNET STEELS."

To the Editor of Engineering.

SIR,—I have read Mr. Crapper's article in your issue of the 2nd inst., on "Suggested Specification for Permanent Magnet Steels" with much interest but a good deal of uneasiness, as while the specifications therein are only suggested, yet there is already evidence that they may be only too readily accepted by certain engineers who have little or no knowledge of the subject.

The wording of Mr. Crapper's last paragraph referring to a suggested specification for magnet steels of the cobalt or cobaltchrome type is unfortunately chosen. He suggests that the figures given therein should be the minimum acceptable. Mr. Crapper must, however, surely realise that the whole question as to what minimum figures are acceptable, must depend upon the price charged for the steel. While altogether omitting any reference to that important consideration, Mr. Crapper brings forward a large number of magnetic properties which, in his opinion, should be included in a specification for a magnet steel of the type under consideration.

I must, however, strongly protest against any suggestion that coercive force, remanent intensity, co-efficient of retentivity, magnetic strength or specific reluctivity at the remanence point, should appear in a specification, as none of the above properties have yet been connected in any way with the weight of steel required for a given energy output, or with any other useful factor for the design of magnets and magnetic circuits, except in so far as all the different properties are inter-related by the complete B H loop.

It has been clearly shown by Mr. Sydney Evershed, Mr. E. A. Watson and others that the only true criterion of magnetic quality and at the same time the key to economic design, is the maximum available energy per cubic centimetre ($\beta \phi$ max.), together with the corresponding flux density. While Mr. Crapper mentions this product at the bottom of his specification, yet he does not in my opinion call enough attention to it, and while given the other constants which he mentions, it would, of course, be possible to construct the curve and so determine the flux density corresponding to the point, yet I think it would be better to state it straight away. To mention magnetic strength ($H_c \times B_r$) in a specification, is surely a waste of time. It signifies nothing at all, and is no guide to the weight of steel required for a given output or to the permanency of a magnet.

A specification is useless unless the tests specified can be rapidly carried out with a reasonable degree of reliability, and the figures given should be such that will give the user all the particulars necessary for the use of the steel. It can be taken for granted that knowing the maximum value of $\beta \phi$ and the corresponding flux density, the required weight of a magnet and its shape for a given purpose can be more or less readily calculated, and until it can be shown that properties such as co-efficient of retentivity, &c., are definitely connected with, say, resistance to shock or resistance to loss of flux with time, their inclusion in a specification can do no good whatsoever. If, however, Mr. Crapper can show any such connection, it is to be hoped that he will publish his results at the earliest possible moment.

In conclusion, I must say that I think it would have been desirable if Mr. Crapper had consulted some of the leading magnet steel makers and users before putting forward his suggested specification, as a suggested specification coming from his pen is very liable to be too readily accepted, and may cause a great deal of inconvenience and unnecessary expense to both magnet maker and magnet user, without in any way assisting either party.

Yours faithfully,

J. FERDINAND KAYSER.

Cannon Steel Works, Carlisle-street, Sheffield, February 13, 1923.

INSURANCE OF WIRELESS APPARATUS.—The increasing use of wireless apparatus is reflected by the action of the Liverpool Marine and General Insurance Company, Limited, who are issuing policies protecting the owners of such apparatus against loss from storm, fire, burglary, theft, &c., as well as from third-party claims.

SOME MECHANICAL PROBLEMS IN THE RUBBER INDUSTRY.*

By H. C. YOUNG, Associate Member.

THE object of the author in placing this paper before the Institution is to draw attention to an industry the life of which depends upon the successful application of mechanical engineering of the highest order. The conditions to be satisfied make exacting claims on the full range of engineering science. The author further hopes to focus attention on some of the heavier classes of plant used in the industry, with the idea of promoting discussion, and of possibly creating a more uniform method of applying the fundamental principles of mechanical design. Only those operations common to all branches of the industry are touched upon in the paper.

General Factory Design.—The world's largest rubber factories are in America, where one factory alone is estimated to handle 2,500,000 lb. of mixed rubber, or over 500 tons of crude rubber, per week. The average American factory requires 650,000 lb. per week of mixed rubber, requiring perhaps 120 tons of crude rubber. Outside America there is probably only one factory demanding more than 700,000 lb. of mixed rubber per week. A recent estimate discloses the fact that in six months American factories utilised 420,000,000 lb. of mixed rubber as against 83,000,000 lb. required by the rest of the world. To-day from 75 per cent. to 80 per cent. of the total output goes to the tyre industry. As recently as the year 1905 factories not connected with the tyre industry took the greater part of the rubber consumed. Table I, page 248, gives physical properties of grades of rubber.

American rubber factories are mainly built in blocks of about 500 ft. in length, and 80 ft. to 100 ft. wide, with five or six stories. This construction is adopted for the sake of economy, and control in heating—an important consideration in a country with an extreme of climate. Capital cost governs the construction in Great Britain; besides, experience proves that for general purposes single-story buildings are the best. Very great advantages are obtained by keeping the building dimensions uniform—for example, columns, design of roof trusses, &c. This enables transfer of plant to be made quickly, lay-outs to be easily adapted, and shafting, hangers, &c., to be standardised. The ground floors of the factory should be maintained at one level, as the nature of the industry makes heavy shop transport one of its chief problems.

The chief points to be considered in deciding whether a factory shall be single or multi-storey are : (1) The amount of land available; (2) initial cost of construction; (3) method of providing foundations to machinery; (4) ventilation; (5) lighting; (6) heating; and (7) convenience, with regard to the operations to be performed.

In this country the average cost of multi-storey buildings is about 30 per cent. more than the single-storey type equipped with the same facilities. It is curious to note that in America this condition is reversed, and the average cost of a multi-storey building is about 25 per cent. less than the single storey. It is naturally more economical to provide a direct bearing on the soil for machinery foundations, for when heavy machinery is placed on an upper floor excessively strong principals are required to support it. Again, the ventilation and lighting of a single-storey building present no difficulty; a natural system of ventilation can be used and top lighting is available. Here the single storey scores by a saving both in initial cost and in the consumption of power and artificial light. In many of the American multi-storey type factories artificial light has to be used even at midday, owing to the fact that the buildings are too wide to allow sufficient light to penetrate from the side windows —of course, no top light is possible except on the top storey. In economy of heating the multi-storey factory undoubtedly has the advantage. It is claimed that when the outside temperature is at zero, the heat required to give an inside temperature of 65 deg. F. would approximate :—

For a multi-storey factory, to one unit for every 9 sq. ft. of floor surface.
For a single-storey factory, to one unit for every 4 sq. ft. of floor surface.
(The unit in this instance equals 1 ft. super of radiation.)

The additional heat required for the single-storey type will not only entail a greater initial outlay, but also an increase in fuel consumption during the winter months. The question as to which type of building will be most "convenient" must be decided from a technical point of view, and no comment need be made here.

Horse-Power and Labour.—Figures given in the *India Rubber World* of July, 1922, show the total amount of primary horse-power available in United States rubber factories to be something like 430,000, and the total number of wage-earners employed in the industry to be 206,000.

These estimates give a load factor of about 0·23 on plant, and the output of rubber per worker, 70 lb. to 75 lb. per week. These figures must be considered only as a rough guide to the industry. Actually, individual factories give something like 100 lb. per worker and a load factor of 0·36 to 0·4. In a factory converting, say, 600,000 lb. of mixed rubber per week into finished rubber goods, one would expect to find employed approximately 6,000 to 7,000 workpeople. Naturally this figure would vary according to the actual processes employed, but it is one that could be utilised when contemplating the lay-out and equipment of a works.

Water.—A primary factor governing the choice of a rubber works site is the water supply. This must be ample, and, during the hot summer months, of low temperature. In many factories outside Great Britain, production is impossible during certain months of the year, water not being obtainable of a sufficiently low temperature, whilst in Great Britain itself, unless water of low temperature is procurable, manufacture of high-grade rubber goods is attended with great trouble. Refrigeration has been resorted to in America, but has only been adopted when it has been quite impossible to proceed without it. The installation of large cooling lakes or ponds is one way of surmounting the problem, when it is not possible to put down more than a limited capacity of bore-well. The highest satisfactory temperature at which water may pass into the factory is about 50 deg. F. A factory using 650,000 lb. of mixed rubber per week will require at least 4,000,000 gallons of water at 50 deg. F. and a second circuit at 66 deg. F. of 4,000,000 gallons per week.

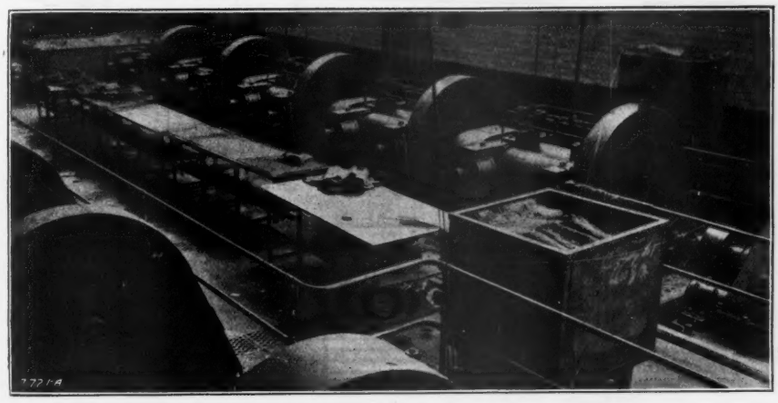


FIG. 1. WASHING BATTERY WITH SOAKING TANKS.

Heating of Factory.—The most economical method of heating a rubber factory is by the utilisation of waste steam from the vulcanisers, and any other waste steam that may be available. As it is highly important that no back pressure should be put on the vulcanisers, it is essential that the waste steam should be circulated through the heating system by means of vacuum pumps. The method usually adopted is to take the discharges from the vulcanisers into the low-pressure distributing mains, and to make connections from these mains for all drying and heating purposes, the return connections of each section of the drying and heating system being taken to vacuum pumps, which remove the air and condensate from the system, and return the condensate to the hot-well after the air has been eliminated. The discharges from the vulcanisers are naturally intermittent, and at times give more than can be absorbed in the low-pressure system; consequently, it is necessary to have a suitable arrangement of relief valves, which will prevent the pressure in the low-pressure system rising. When there is not sufficient waste steam from the vulcanisers, &c., to supply the heating and drying requirements, live steam can be admitted automatically through a reducing valve, to keep the low-pressure system fully charged. The savings which can be effected by the utilisation of this waste steam are remarkable, as instanced in five rubber mills. The waste steam from the vulcanisers was used for heating in lieu of live steam, and the savings effected on the total coal consumption of the mills are indicated by the figures in the next column.

	Per Cent.
Mill No. 1	15
Mill No. 2	17½
Mill No. 3	25
Mill No. 4	28
Mill No. 5	50

The difference in these savings is explained by the fact that in some of the mills, the proportion of steam used for power was greater than in others. In other mills the power is generated by means of turbines, with a pass-out connection, from which steam is taken at about 60 lb. for vulcanising purposes; and if the demand for process steam is large in proportion to the steam required for power, a considerable saving can be effected by the adoption of this system; but if, on the other hand, the demand for process steam is comparatively small in proportion to power, it is probably most economical to leave the turbine purely condensing, and use live steam for the process work, utilising the waste, as explained above.

In a rubber factory the heating and maintenance of its departments at constant temperatures, and the necessity of increasing or decreasing any temperature on sudden demand to cope with changes in the height of the dew-point, are some of the chief cares of the engineer. The successful manipulation of a rubber plant depends in a large measure on the flexibility of the heating apparatus, for the materials to be worked must be kept within narrow limits of temperature and humidity in many of the operations. The heating system should be so sectionalised that it is possible to increase or decrease the temperature in any shop or section thereof, without necessarily affecting adjacent sections.

Ventilation.—The condition of the atmosphere has a definite relationship to the ease of production. The factory should be maintained at 65 deg. to 70 deg. F., with the dew point at least 15 deg. F. below in shops where there are no solvents, and 20 deg. F. where solvents are present. If the dew point becomes high, the shop temperature must go up.

Dust.—One very serious matter the engineer in the rubber factory must face is the dust problem. Chimney stacks, belonging to or adjacent to the factory, stacks of fuel, dusty thoroughfares, rail tracks, &c., should all be on the lee side (prevailing winds determining this). The roof and roof openings should be such as to prevent the dust gathering in the gullies and blowing through the openings. Only the minimum amount of overhead shafting and pipework should be tolerated, and provision must be made for regular cleaning of the roof girders. Cement or plaster on the under portion of roofs or ceilings should be fixed, and papered over if necessary, when, owing to vibration, there is danger of flaking. These remarks also apply to the floors, the ideal flooring for a rubber factory being maple. Other forms of flooring give considerable trouble from dust, and floors such as "bitumastic" are not successful because the temperature of the shops varies between 65 deg. and 85 deg. F. Loads transported on elevating trucks are heavy, and the hard floors are ground up by the small diameter wheels, while soft floors develop tracks. One has either much dust or difficult transportation to contend with, but rubber floors might, however, be tried. Truck wheels have been tyred with rubber, and the comparison between a fairly hard rubber tyre and a steel wheel shows that the pull required with rubber tyres at the start to be 280 lb., and for the steel wheel 168 lb.; to maintain the pull 186 lb. and 84 lb. respectively; the figures were taken with 2,000 lb. load on wheels of 6 in. diameter, 3 in. wide.

In the production of finely-ground and calendered rubbers, where articles are made of thin sheets, such as motor and cycle tubes, surgical requisites, and cables, &c., specks of dust would destroy the product, and it is therefore best to install some system of vacuum cleaning. The figure quoted of the number of workers in a rubber factory will indicate the abundance of dust that can be taken in on the employees' footwear. The act of sweeping up this dust in the ordinary way lifts it from the floor level on to the work tables, machines, &c. The only satisfactory method of surmounting the difficulty is to install a vacuum cleaning centre in each department, with piping running the whole length of each shop, where necessary in parallel lines, with branch tubes for flexible connections, for use with a suitable type of vacuum floor brush.

Sweeping Process Powders.—The advantages of a vacuum system for taking up dust, where the dust is caused by process powders, are pronounced. Powder saved by the vacuum cleaning, as against the quantity collected by ordinary floor sweeping, amounts to about 50 per cent. with recent tests. Powders salved by vacuum process can be made fit for use again, whereas with sweeping it is found difficult to procure brooms which do not distribute particles of bristle into the powders, and these bristles will invariably pass through any sieve used for powder preparation. The ordinary broom method of sweeping is useless for cleaning girders, in and around machinery, mixing mill hoods, &c. With a vacuum system the chief difficulty is that of getting an efficient filter. Several have been tried, but the muslin covering of the filter bag which is supplied with most of these systems becomes clogged, pressure in the bag is set up, and the bag bursts. This so often interrupts the working of the plant as to make it an unprofitable proposition. An attempt has been made to use a water filter, but such a method precludes salving of the powders. They are formed into a paste and the subsequent cost of handling, drying and sieving is prohibitive.

The system of bag-shaking dust extractors is good, but the installation of this huge plant is costly, requiring considerable floor space, and, owing to its construction, it will not stand the high vacuum that floor cleaning needs. Such machines as the Beth extractor are suitable for sieving and drying plant as described elsewhere, but

* Paper read before the Institution of Mechanical Engineers, on Friday, February 16, 1923.

require large trunkings for their successful operation, and would not be practicable in a rubber shop 700 ft. in length, as a length of piping of at least 350 ft. and a vacuum of about 20 in. would be required.

Lighting.—Efficient lighting is most essential, because of the black stock used in the manufacture. Reflection in the drug and mixing departments is practically nil, and the subject of lighting in all departments needs great consideration.

Piping and Cable Trenches.—It is vital that the greatest care be taken in laying out the pipe and cable work, keeping it as much as possible outside the process shops. All main controlling valves and switches should be placed exterior to departments. The method adopted in a modern rubber works to-day is similar to that used for internal transport by some of the Lancashire engineering concerns, and that adopted by asylums for their pipe-work, using subways running beneath the shops, with cross-subways linking up the factory buildings. In American factories the practice of providing a tunnel 20 ft. wide underneath the factory buildings is common. This has the undoubted advantage of providing better control of all mains, in addition to the fact that repairs, overhauls and alterations are carried out exterior to the shops involved.

Factory Operations : Washing.—The usual practice is to arrange a line of five washing machines, consisting of one breaker, two washers and two sheeters. There is no agreed design of roll to give the most efficient washing output, and there is no standard machine. Few figures are available to show what output the machines are capable of against grade and method of washing. Washing is usually performed in three operations, that is, breaking down on the first set of rolls, after soaking or heating,

Fig. 2. VARIOUS DRIVES FOR MILLS.

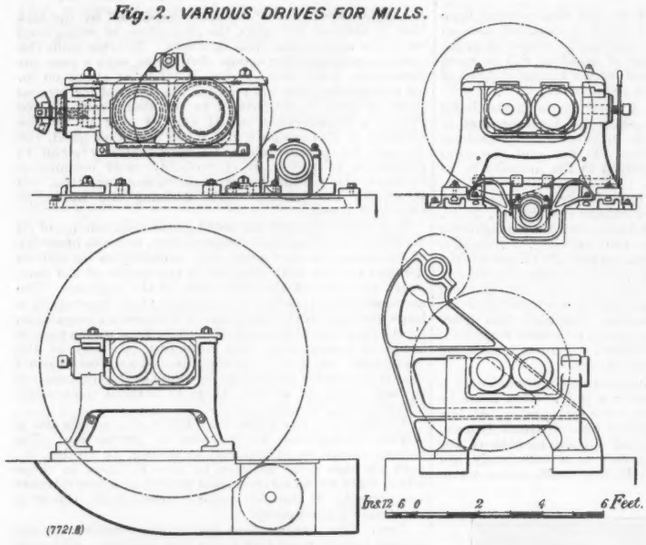
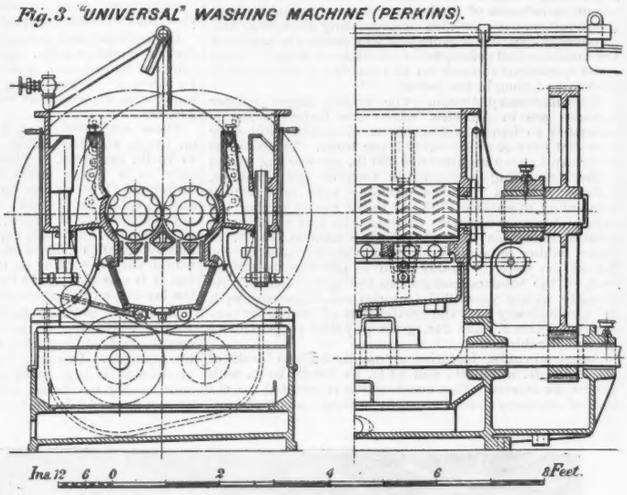


Fig. 3. "UNIVERSAL" WASHING MACHINE (PERKINS).



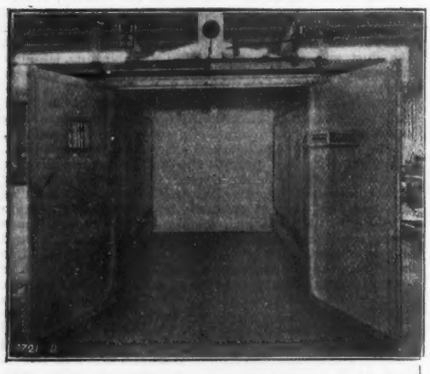


FIG. 4. KILN-DRYING CELLAR (HUNTER).

Fig. 5. KILN DRYING CELLAR (HUNTER).

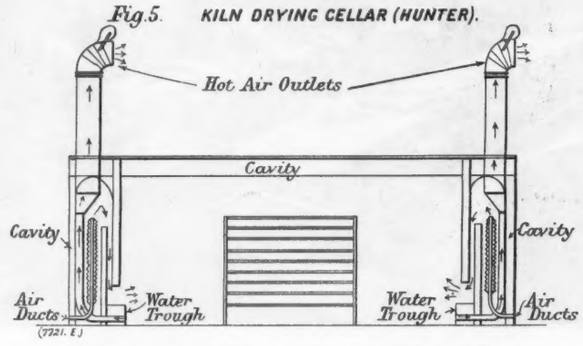


TABLE I.—*Examples of Physical Properties of Rubber in its Various Stages of Manufacture.*

Grade of Rubber.	Tensile Strength, Kg. per Sq. Mm.		Percentage Elongation at Break Point.		Compression 0·07 Ton on 2-In. Cube.		Specific Gravity.	
	A.	B.	A.	B.	A.	B.	A.	B.
					mm.	mm.		
No. 1 plantation ..	0·23 apprx	0·016	800	458	10·0	24·8	0·87	0·87
No. 2 plantation ..	—	0·016	—	394	6·8	29·0	0·86	0·86
No. 3 plantation ..	—	—	—	—	8·8	25·5	0·88	0·88
Fine hardPara	0·65	0·017	600	457	—	21·5	0·88	0·88
Loaf	0·70	—	650	—	9·3	—	0·92	0·92
Smoked sheet	0·68	0·021	440	451	4·1	26·0	0·90	0·90
	C.	D.	C.	D.	C.	D.	C.	D.
Cures soft mix	0·005	1·42	461	812	31·0	13·63	1·01	1·02
Cures hard mix ..	0·218	1·80	397	180	7·9	1·7	1·17	1·22
Cures very hard mix ..	0·20	3·48	534	0·25	15·2	0·10	1·37	1·41

The different states of rubber are : A, Raw rubber ; B, masticated rubber ; C, mixed ; D, vulcanised rubber.

NOTE.—The tensile strength and elongation figures given for raw, masticated and mixed rubbers cannot be taken as absolutely accurate as these figures depend largely on the rate of loading. The specific gravity figures for Nos. 1, 2, 3 plantation and fine hard Para rubbers are slightly low owing to the porous nature of these rubbers. The air can only be totally extracted by placing under a vacuum pump for some time.

TABLE II.—SPECIAL TESTS FOR COMPARING WASHING MILLS.

Line.	Class of Mills.	Roll Size. Diam. in.	Front Roll Speed.	Friction Ratio.	Kilowatt-Hours per Pound, Washed. A.	Kilowatt-Hours per Pound, Washed. B.	A.	B.	Output per Hour. A.	Output per Hour. B.	Remarks.
					Crêpe.		Smoked Sheet.		Crêpe.		Batch Size.
Fast 30-in. length	1 breaker	16	24·4	1 : 1	0·025	0·015	0·017	0·016	940	1,064	A = 12 lb.
	2 washers	16	20·91	1·16 : 1	0·050	0·040	0·044	0·039	Smoked sheet		B = 20 lb.
	2 sheeters	16	22·07	1·105 : 1	0·040	0·031	0·033	0·030	960	1,100	
					0·115	0·086	0·094	0·085			C = 6 lb.
Slow 30-in. length	1 breaker	16	19·8	1·11 : 1	0·015	0·012	0·014	0·011	Crêpe.		D = 40 lb.
	2 washers	16	12·6	1·57 : 1	0·038	0·034	0·035	0·030	840	1,000	E = 60 lb.
	—	16	14·8	1·65 : 1	0·041	0·036	0·037	0·033	Smoked sheet		F = 80 lb.
	2 sheeters	16	12·6	1·37 : 1	0·032	0·028	0·030	0·020	900	1,020	
	—	16	15·6	1·1 : 1	0·029	0·025	0·028	0·019			
					0·085	0·073	0·079	0·062			
					A.	C.	A.	C.	A.	C.	Smoked sheet is soaked at 212 deg. F.
Slow 24 in. *	1 breaker	16	16·6	1·50 : 1	0·025	0·035	0·024	0·033	Crêpe		
	1 washer	16	16·6	1·50 : 1	0·049	0·065	0·048	0·064	851	752	Crêpe is soaked at 120 deg. F.
	3 sheeters	16	22·22	1·12 : 1	0·041	0·050	0·040	0·048	Smoked sheet		
					0·115	0·150	0·112	0·145	880	768	
					D.	E. F.	D.	E. F.	All grades.		* Breaker and washer on this line 30-in. length.
—	Perkins washer	40 × 14	9	1·4 : 1	↑ 0·132	↑ 0·100 ↑ 0·099	0·132	0·106 ↑ 0·104	D 120		† Includes power required for sheeting out.
					Tree Scrap.		Gutta Percha.		E 180		
					↑ 0·140	↑ 0·113 ↑ 0·108	↑ 0·132	↑ 0·108 ↑ 0·105	F 240		

washing on less aggressive rolls, and finally milling into sheets, which are gauged for width, length and weight. A battery of washers is shown in Fig. 1.

The face of the breaking down roll has usually a lozenge pattern cut on it with grooves $\frac{1}{8}$ in. deep. To ensure the even wear of the lozenges the circumferential grooves are sometimes of very coarse pitch. There has been no attempt to link up the horse-power, output and form of groove.

The machines have no definite location for the rolls to keep the grooves in line, with the result that the rolls wear and ridges are formed on the roll face. This ridging is in effect a series of saw teeth on the front and back roll, which fit into one another, and the rolls in this state compared to when first installed have a very poor appearance. It has been found by horse-power tests that these much worn rolls are actually as effective as new ones, and this suggests that the rubber is better worked by a roll with tooth meshing. Owing to the quantity of water continually going into the nip of the rolls, there is no necessity to have them bored, to carry away the heat generated by the milling operation. When starting up cold, steam connection must be made for heating the rolls. A battery of five washing machines, with roll lengths between the cheeks of, say, 30 in., require 150 h.p. The machines must be designed so as to prevent oil and grease from the bearings creeping on to the roll face, which, besides affecting the rubber, causes slippage. In addition, sand, grit and acid from the rubber must be prevented from working into the bearings. Water should not be allowed to wash out the lubricant, nor should rubber be allowed to lodge between the roll necks or behind the guide plates.

The design of the breaker and washer rolls must be such as to permit no unbroken ridges of rubber to pass through the nip; an efficient washer should break open every particle of rubber, to allow the water to wash out all foreign matter. The horse-power per operation is shown in Table II, and from this it will be seen that, although the machines are planned on the assumption of equal stresses (as the only difference between sheeters, washers and breakers are the roll faces), quite a considerable difference takes place. A 150-h.p. motor driving the battery described might be set to trip at 25 per cent. overload, with a 15-second time relay, approximately 180 h.p. If at any instant only four machines are running, giving the motor 60 per cent. to 70 per cent peak load, overload can be applied at fairly regular intervals, and the machines should be made to stand up to these shocks.

Various arrangements of mill drives are shown in Fig. 2.

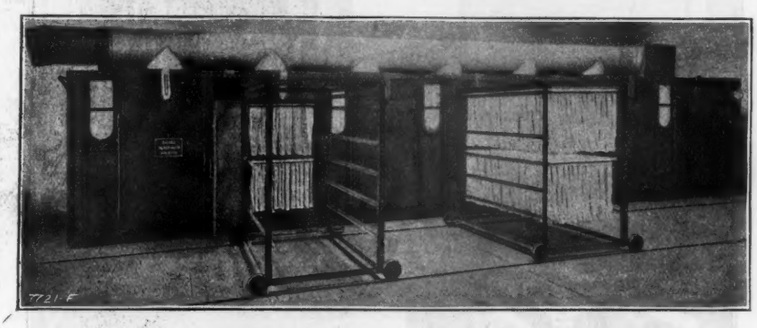


FIG. 6. DRIER (TOMLINSON-HAAS).

Fig. 7. "SIMPLEX" DRYING MACHINE (TOMLINSON-HAAS).

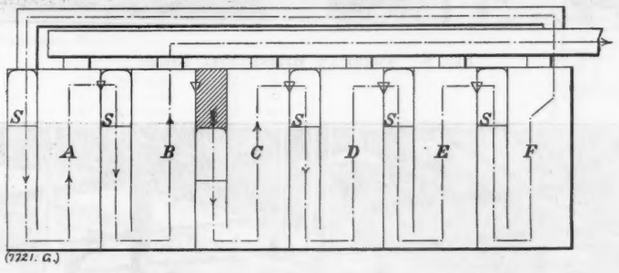


TABLE III.—SPECIAL TESTS FOR COMPARING MILLS.

Mill Specification.						Masticating.				Mixing.				Remarks.
Type of Mixer.	Material.		Speed of Rolls, R.P.M.		Friction Ratio.	Temp. of Stock.	Gallons Water per Lb. Rubber.	Kw.-Hr. per Lb. Rubber.	Output per Hour.	Temp. of Stock.	Gallons Water per Lb. Rubber.	Kw.-Hr. per Lb. Rubber.	Output per Hour.	—
in.	front	back	front	back		deg. C.			lb.	deg. C.			lb.	
54.. ..	C.I.	C.I.	8·9	15·6	1·75 : 1	67	8·0	0·191	120	80	10·8	0·161	133	* This includes power required for sheeting out rubber.
60 Slow ..	C.I.	C.I.	9·46	13·17	1·39 : 1	68	3·1	0·196	180	79	5·1	0·179	185	
60 Fast ..	C.I.	C.I.	13·24	19·87	1·5 : 1	82	8·2	0·228	210	95	12·9	0·181	215	
84 Medium	C.I.	C.I.	11·49	14·48	1·5 : 1	76	8·5	0·199	262	94	12·0	0·179	250	
84 Slow ..	Steel	C.I.	8·45	10·75	1·5 : 1	71	—	—	—	76	4·2	0·172	250	
84 Medium	Steel	C.I.	11·49	14·48	1·5 : 1	76	—	—	—	88	5·4	0·178	300	
84 Fast ..	Steel	C.I.	15·4	19·6	1·5 : 1	95	4·1	0·231	345	No figures available.				
Banbury	—	—	38·0	42·0	—	114	No figures available	No figures available		120	No figures available	0·135*	340	
Perkins ..	—	—	8½	5¼	—	—	,,			90	,,	0·120*†	300	
Farrel ..	—	—	20	—	—	—	—	0·31	360	120–140	,,	0·175*†	500	
	—	—	14	—	—	—	—	—	—	120	—	0·126	1,248	High powder content 1·7 Sp. Gr.

NOTE.—The kilowatt-hours per pound figures on the Banbury and Farrel mixers were calculated from the average ammeter reading and are therefore not so reliable as the remainder of the readings which were taken direct with a kilowatt-hour meter. The rubber used for these mixing tests was of a medium grade, specific gravity of about 1·3, tensile strength when cured of 1·5 kg. per square millimetre approximately, except those which are marked †. In these tests a mother stock of rubber and gas black was mixed. The latest figures quoted for automatic mixing, but which are not free for publication, show very much reduced temperature and power consumption figures.

Overload on a Washer (Perkins).

All Batches Washed for 20 Minutes.

Batch.	Tree Scrap.	Smoked Sheet.
lb.	h.p.	h.p.
40	17·5	16·5
138	51·5	37·0
183	61·2	44·0

The arrangement of drive for best production is to have the rolls free for approach from front or back, which necessitates the backshaft being placed above the machine or below. The backshaft being placed a little above floor level, and at the rear of the machine, is best purely from the maintenance and attendance point of view. Placing the line shaft over the battery has the disadvantage of casting shadows on to the nip of the roll, and makes it possible for grease and oil to drop on the working portion of the roll. This arrangement keeps the shaft away from water, grit and acid, but attention from the engineers is then likely to interfere with production. The line shaft placed below the rolls, giving a clear floor space in front and behind the machine, was the practice adopted when mills were direct driven by steam engines, and many more mills were driven off the one shaft than is the custom to-day. With a long line of mills, to make shop transport possible and to avoid the use of ramps, the line shafts were placed below the floor level. This position for the shaft makes it more difficult for maintenance, repairs and replacements to be effected, and the difficulties of inspection and attendance are increased. The factors that affect the horse-power per pound of rubber washed and the labour cost per pound are: (*a*) Speed of roll; (*b*) ratio of back roll to front roll speed; (*c*) type and pattern of roll; (*d*) width of roll face; and (*e*) metal of rolls. Horse-power consumption, and the necessary design of mill, limit the speed and size of washing rolls, although this limit has not been defined (see Table II). With regard to ratio of back to front roll speed or friction ratio, even speed rolls give less output, and less working and tearing of the rubber, and also increase the pressure on the bearing. There is no settled rule governing the friction ratio. The type of roll varies considerably, but tests indicate that the coarser the pattern on the roll, and the deeper the grooves, the better the results. This, no doubt, is because the rubber is displaced more when passing through the nip with coarse pattern rolls, but superior results are obtained if the rolls actually corrugate the rubber on the machine, and at the same time a friction ratio of 1·5 to 2 is required to create sufficient tearing action. Since length of roll controls the whole dimensions of the machine, this is reduced to give reasonable roll bearing and wheel dimensions. The sheeter is of such a width as to give suitable sheets for hanging or placing on trays, narrow rolls being used where thin sheets are required for specially clean rubber.

Most makers supply rolls made of chilled cast-iron. In practice these are not the best because they allow too much slipping; a good grey iron gives a far better result, and although the rolls have to be renewed more frequently than those of chilled cast-iron, if the rough surface can be retained, it pays to use the non-chilled roll in spite of the increased cost of the roll renewals. With chilled cast-iron rolls piece workers have been known to use sand to get the rolls to grip. The wear on the rolls and bearings is very considerable, because of the action of sand, water and acids from the rubber.

Universal Washer.—The totally-enclosed washer with fixed rolls is the alternative to the standard mill. The action of this machine is to tear the rubber with two fixed centre rolls possessing deep corrugated faces, and as the rubber passes through the nip it is split on the knife-edge below nip and turned over by a further nip before going through again. The whole is contained in a watertight case, so arranged that it can be flooded with either hot or cold water, which washes away all loosened sand, grit and other foreign matter. These machines are used with profit chiefly for the lower grades of rubber, and for washing on the plantation. In a washing battery they replace the breaker and washer, but need a sheeter to finish the work. It is with this class of rubber machinery that bearing and gear dimensions assume increased importance, and a generous proportioning is necessary to ensure success. A comparison of horse-power figures with bearing and roll neck dimensions will give some indication in this direction. Stuffing-boxes and glands must be of ample dimensions and easily accessible for packing. A split flange fitted between the glands and bearing could be arranged to throw the water leaking past the gland. The comparison between the ordinary washing machines and that of the Universal type of washer, illustrated in Fig. 3, can be made by reference to Table II (page 248).

There is still room for a machine capable of handling both low and high-grade rubbers, and it is questionable whether the machine should not be proportioned on very much increased dimensions, with perhaps a higher horse-power consumption, but with capacity for breaking up the rubber more quickly, and more efficiently exposing fresh layers of the mass to the water stream. This might with advantage have greater pressure and volume, and so clear out the grit and sand without working the rubber so much as is done on the present standard machines. Finally, the rubber can be dry-sheeted, ridding it of all surface moisture. This obviously assists the process of drying and mastication. Washing machines, unless they are very carefully loaded, and the batches kept on the small side, are a continual source of worry to the maintenance engineer. Most grades of rubber are sufficiently dry when received from the plantation to go into manufacture without further drying, but in the process of washing, the rubber absorbs moisture to the extent of 2 per cent. to 3 per cent., and even 4 per cent. This moisture is found uniform through the mass, and not adjacent to the surface only. As the maximum moisture tolerated is 0·5 per cent., washing therefore requires the installation of a thorough drying system.

Washing, Shop Drains.—In washing low-grade rubbers, in fact, most grades, small particles of rubber are washed through the various trays, with grease and other foreign matter, into the drains, and it is essential that all drains be supplied with traps to prevent this rubber getting away. In some American factories it is the practice to allow it to pass through open drains to a large settling tank, where a hopper conveyor skims the rubber from the surface. The conveyor is halted periodically and the hoppers cleaned of rubber adhering to them. To reclaim this waste successfully it must be free from oil or grease. This again adds importance to the design of bearings to prevent leakage of oil.

Drying of Washed Rubber.—The dryness of the rubber

and powders in compounding the "mix" or "dough" is necessary to prevent the porosity of the mixture during the "forming" or "moulding" process. The presence of moisture at the high temperature to which the goods are submitted in the vulcanisers would cause blow-holes, &c. The aim in the drying operation is to bring the amount of moisture in the "dried" rubber to below 0·5 per cent. when it leaves the drying cellars or stoves. If more than this amount of moisture is retained in the rubber, a loss of time and power is experienced in the next step of manufacture, namely, the mastication or plasticating of the rubber on the mills. Rubber with 2 per cent. to 3 per cent. moisture will work up into crumb on the mills. A quantity of rubber was washed and hung in a drying stove and 200 lb. batches removed at various periods. The moisture content was determined after various periods of drying, and rubber then put on an 84-in. hot masticating mill and the moisture content again determined after different periods of time of mastication. It was proved from the tests that it is economical to dry the rubber to the limits mentioned, by means of warm chambers rather than on the mills. The drying of rubber has not till recently received the attention it merits.

Before examining types of driers, it is necessary to consider the different factors involved in drying rubber to the limits required. These are: (*a*) Period of soaking before washing; (*b*) weight and thickness of sheet; (*c*) temperature; and (*d*) atmosphere.

Each factor influences the period of time permissible between washing and mastication, and the shorter this period the smaller are the stocks of rubber that need be carried.

(*a*) *Period of Soaking before Washing.*—The rubber must be softened by some means before being put on the washing mill, and this can be done either by soaking in hot water for a period of time up to 24 hours or by placing in a warm stove for a given time; in practice the soaking method is quicker and more advantageous, but it is found that the time of drying required by the washed rubber is proportional to the length of time the rubber is soaked, and that the thicker the slices of the rubber before soaking, the less water is taken up by the rubber during soaking. The time of soaking has a direct effect on the time of drying, and test figures definitely prove that it is necessary to reduce the soaking period to the minimum to obtain a quick drying time.

(*b*) *Weight and Thickness of Sheet, and* (*c*) *Temperature.*—To test the effect of the thickness of the sheet of washed rubber on the time of drying, sheets of rubber from one plantation were taken and given the same time of soak, &c., and made into 5 lb. to 35 lb. sheets of different thicknesses, but of the same area, and dried under similar conditions at four different temperatures, drying being done at 100 deg., 110 deg., 120 deg. and 130 deg. F. The drying time was not affected at 100 deg., 110 deg. or 120 deg. F. Above 120 deg. F., where drying is accelerated, the rubber sheet shows a tendency to slower drying with an increase in thickness. The time of drying is, of course, shorter with the increased temperature, but rubber sheets cannot be hung over 130 deg. F. conveniently, requiring to be dealt with on trays when this figure is exceeded. The temperature, however, is limited by the rubber becoming "tacky"; the point at which tackiness commences is about 130 deg. F. to 150 deg. F., depending on the grade of rubber, oxidation may also take place under these circumstances.

(*d*) *Atmosphere.*—The temperature of drying can be raised if done in a vacuum, but the rubber must be laid out on trays, which proves a slow method when bulk production is required. The influence of the air current on the rate of drying is shown by the following example of a stove which was partitioned into sections by means of screens to force the warm air to flow over a larger area of the dry sheets of rubber. On one side of the stove the air was allowed to flow in a direct line to the outlet, and in the other half of stove the air was made to pass over baffle screens, diverting it up and down the rubber sheets. The same washed rubber, hung in the various sections of the stove, was tested for the percentage of moisture it contained each day for five days. The result showed that in three days the rubber in the section of cellar using baffles had 0·75 per cent. moisture, while the other had still 1·4 per cent. The air velocity and direction are thus of considerable importance in the efficiency of drying. Humidifying the air is claimed as a means of accelerating drying and improving quality.

Types of Drying Stoves.—Various types of driers have been devised for the quick drying of rubber to give the necessary conditions to reduce the period of time to the minimum consistent with quality, and the first form is that of the ordinary warm air-chamber. The operators must enter the hot cellar to hang and remove the rubber, which is a great drawback. The temperature is usually about 110 deg. to 120 deg. F., and is maintained at the period of time drying, which, including loading and unloading, is about 72 hours. The latest American drier is a distinct advance on most drying schemes. In this drier, Fig. 4, advantage is taken of a high temperature, the drawbacks of which are overcome by simple means. The sheets are laid on trays, and prevent rubber dropping; the trays are placed on trucks capable of being loaded at the washing mill, being pushed directly into the drier as required, and removed when the rubber is dry. This obviates the operators having to work in the high temperature and unpleasant atmosphere of the stove. In addition, the drying may be made a continuous process without cooling the chamber to any appreciable degree. Possible oxidation of the rubber is prevented by humidifying the warm air in the drier, and it is claimed in addition that this humidified warm air softens the rubber, giving subsequent saving of power in the next process, namely, that of mastication.

The practical arrangements of the drier are shown in Fig. 5. It consists of a chamber surrounded by an air space to prevent radiation or loss of heat, the air flowing in at the bottom of the stove, at each side through small ducts. It then passes through steam-heated radiators and over a tank of warm water, as shown. The outlet for the moist air consists of a trunk arranged at the bottom of the drier and connected with a stack, the circulation of the air depending entirely on the displacement of the cold air. The temperature maintained is 160 deg. F., and the period of drying is 24 hours. Drying in 6 hours is claimed for this cell.

The Tomlinson-Haas Simplex drying machine (Fig. 6, page 249), is one that has been used for many years in the textile industry, and is eminently suitable for rubber drying. Although comparatively unknown in the rubber industry, it has many advantages over the other driers. The rubber can be hung on trolleys at the washing mills and wheeled into drying cells, which are arranged to allow the principle of "counter currents" being used. Fig. 7 shows a section of the drier, which consists of a series of drying compartments usually arranged as a unit of six or eight chambers. As the operator empties and reloads the drying chamber from the left to the right, it follows that the first chamber opened will be the driest, the next a little wet and so on, the last chamber on the left being the wettest. In the latest type of this drier steam inlet jets are provided at a point which enables the

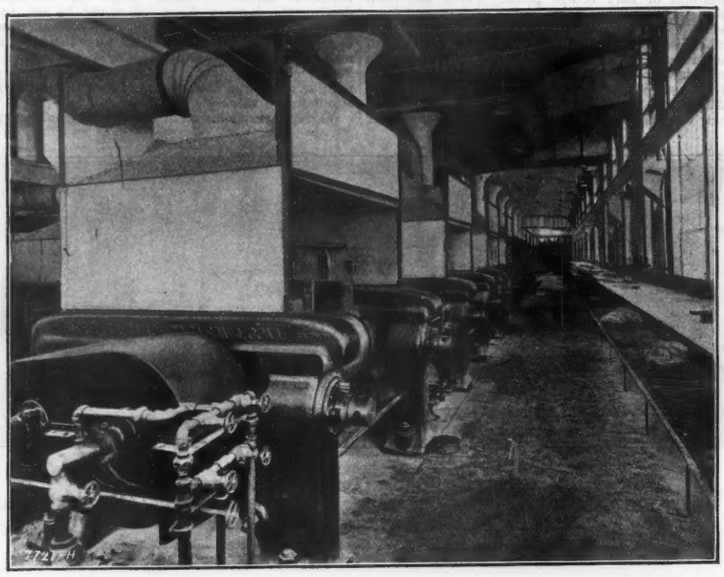


FIG. 8. AMERICAN MIXING MILL ROOM.

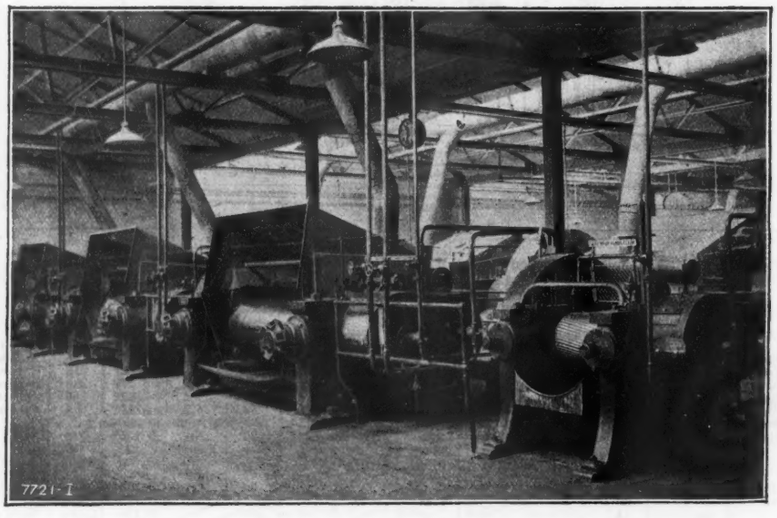


FIG. 9. ENGLISH MILL ROOM.

Chamber in Fig. 7.	—	—
	deg. F.	
C.	158	These temperatures were used for drying hanks of yarn.
D.	176	
E.	210	
F.	225	
A.	234	
B.	240	

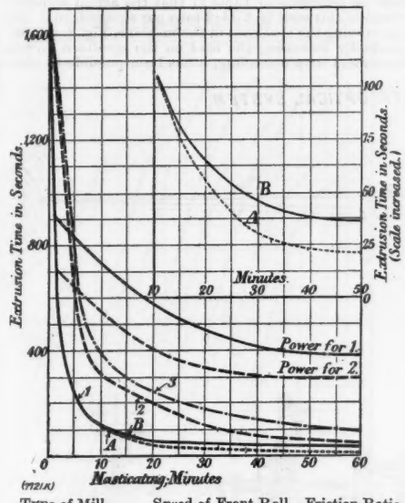
Time of Drying.	Temperature of Drying.	Moisture in Rubber.	
		Smoked Sheet.	Pale Crêpe.
hours.	deg. F.	per cent.	per cent.
Nil	Nil	2·92	3·48
1	80–100	2·38	1·98
1½	80–100 1 hour 110–120 ½ hour	1·94	1·69
2	80–100 1 hour 110–120 1 hour	1·90	1·40
2½	80–100 1 hour 110–120 1½ hours	1·75	1·75
3	80–100 1 hour 110–120 2 hours	1·42	1·55
3½	80–100 1 hour 110–120 2½ hours	0·86	1·13
4	80–100 1 hour 110–120 3 hours	0·82	1·08
5	80–100 1 hour 110–120 3½ hours	0·76	1·01
6	80–100 1 hour 110–120 4 hours	0·60	0·96

air to be humidified at will, and this permits all the advantages which may be gained in the other driers to be used with that of Tomlinson-Haas. The figures in the small table on the previous page show the increase in temperature of the chambers, as the air passes over the increasing number of heating sections.

The time and temperature of drying rubber in a drier of the type shown in Fig. 7 carried out some time ago on a twenty years old machine are also given on page 250. The present-day plant is much more efficient.

Vacuum Drying.—The drawback to this type is that the rubber at the "nip"; for the rolls being bare of rubber they cool more readily. In addition, the sheet of rubber cools very considerably as it enters the tray. This method can be arranged to be automatic. The alternate method is to allow the rubber to embrace the front roll, then continuously cut it over by hand, changing the rubber so that a fresh layer always embraces the roll. If there were no "cutting about," the rubber would be unevenly worked. Neither of these methods can claim to be anything but elementary, but it is safe to say that 95 per cent. of the world's rubber mixing is being carried out by one or other of them. The lack of control of speed, mill friction and temperature, give rise to the need of experienced workmen, particularly on delicate mixings.

Fig. 10.

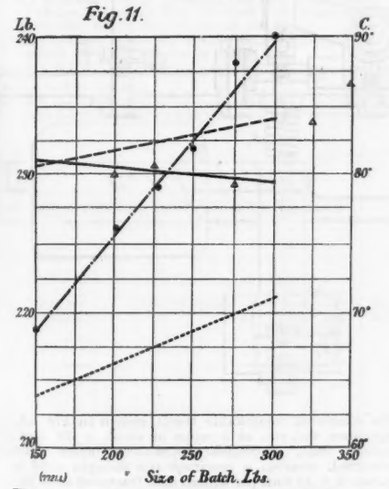


Type of Mill.	Speed of Front Roll.	Friction Ratio.
1 = fast 84 in.	89 ft. per min.	0·5 to 1
2 = slow 84 in.	47 ft. per min.	1·5 to 1
3 = slow 84 in.	47 ft. per min.	1·07 to 1

A = rubber masticated only 10 min. at a time on mill.
B = rubber masticated continuously.

NOTE.—The "extrusion line" is a measure of the "hardness" or the reciprocal of the plasticity figure of the rubber.

Fig. 11.



These tests were carried out on a line of four 84-in. mills with a soft grade rubber.

——— Units of power per pound. Rubber mixed. $\frac{1}{3}$ in. = 0·02 kw. hours.
— — — — Output rubber mixed per hour. $\frac{1}{3}$ in. = 2·5 lb.
- - - - - - Temperature of rubber. $\frac{1}{3}$ in. = 2·5 deg. C. on slow mills.
— — — — Temperature of rubber on fast mills.

a large amount of handling is involved with a limited output. The drier is, however, very effective.

Masticating and Mixing Mill.—The function of the mixing mill is to prepare the rubber for taking drugs, &c., and to mix the drugs and rubber thoroughly to produce a uniform mass. Views of typical American and English mixing mill rooms are given in Figs. 8 and 9. The practice of some American mill rooms is to grind the rubber until it is sufficiently masticated to take the drugs, then to cut off the whole mass, placing the batch on a special even speed mill for drugs, again cutting off and mixing on a separate mill with a friction ratio of 1·5. This is not a good practice, but if the mill speed and friction ratio are studied, an economy in power might be effected. To mix the rubber thoroughly, it must first be masticated on the mill. The rolls are set tight up and the batch ground through. This method has a distinct advantage, in that it cools

DIAGRAMS OF AUTOMATIC MIXERS. (FARREL.)

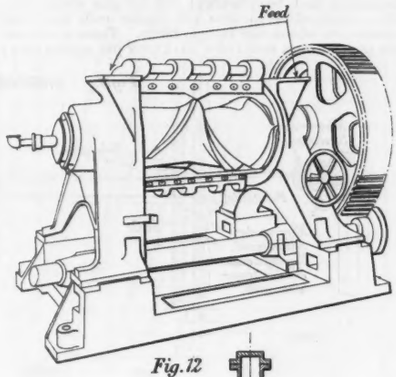


Fig. 12

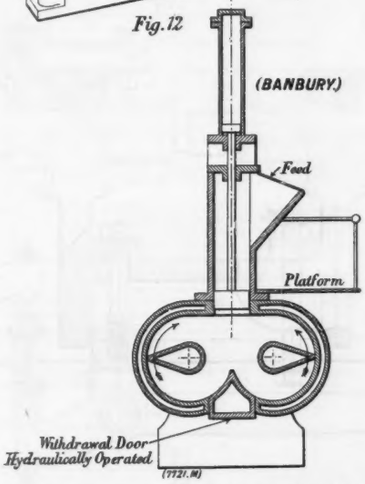
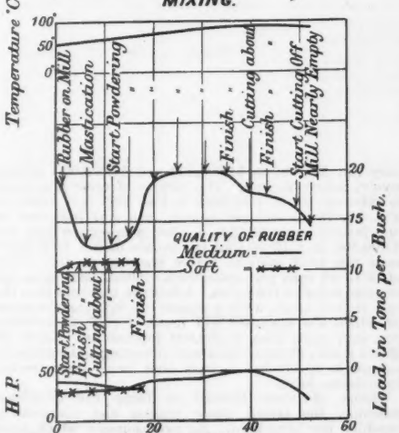


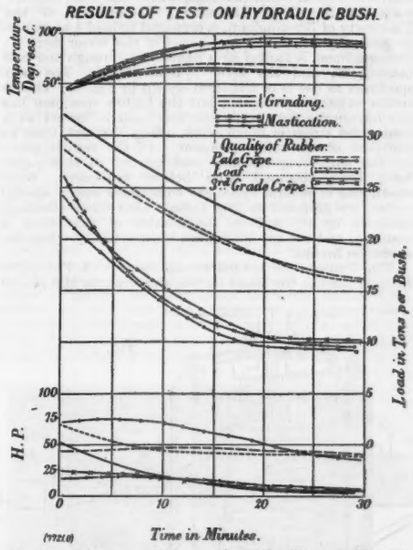
Fig. 13. RESULT OF TEST ON HYDRAULIC BUSH. MIXING.



So heavy is the horse-power bill for rubber mixing that many remedial devices have been introduced, but until quite recently no real advance has been made. The totally-enclosed automatic mixer has now become established, and has reduced the horse-power consumption by half, but it does not possess the flexibility necessary for the standard milling operation.

Automatic Mixers.—Makers of automatic mixers claim for this type of machine: Uniformity of mix; control of temperature; less punishing of the rubber as the work is done throughout the mixing chamber and not in a nip; reduced labour costs; reduced horse-power consumption per pound of mixed rubber; removal of the dust nuisance and saving of waste powder.

Fig. 14. MASTICATION OF RAW RUBBER ON 60-INCH MILL. RESULTS OF TEST ON HYDRAULIC BUSH.



One machine, as will be seen from the diagram, Fig. 12. annexed, consists of a mixing chamber with two fixed centre mixing blades, so shaped as to cut open the mass of rubber in the chamber, and continually present new surfaces to the machine; it also brings the surface in contact with the drugs. The Farrel machine uses one roll only, specially grooved, with a ribbed cylinder. To be successful these machines must be efficiently cooled, of ample mechanical dimensions, and should be fitted with a couple of rolls for sheeting out, as the batch just tumbled out of the mixing chamber is awkward to handle, and likely to burn unless sheeted out quickly and allowed to cool. It is very questionable whether they are capable of mixing satisfactorily stock to which sulphur has been added; the best results so far have been obtained by adding sulphur on the sheeting mills.

A British invention in 1919 might have gone a long way towards solving the difficulty, but no results have as yet been published. The method was to drive the front and back rolls independently, by means of variable-speed motors, thus obtaining the speed and friction ratio best suited for a particular stock. This idea has great possibilities, because the different qualities of mixture require different speeds and friction. It is found, for instance, that even speed is best for powdering; high friction ratio and high speed best for mastication; whereas for mixing there is a distinct limit for the speed, and the same for "cutting off." The stock changes so much and is influenced by supply and market price to such an extent that flexibility is essential. Up to the present this point has received little attention. Usually the only way possible to produce tender mixes is to reduce the batch dimensions, and, when the stock temperature becomes excessive, dropping in a tray to cool, which is a costly method. Horse-power consumption has also been increased by the general unbalanced design of the mill. Apparently no attempt has been made to reduce the huge friction losses on line and mill bearings. Figs. 13 and 14 show the character of the loads on bearings in mixing and masticating mills, and give the horse-power taken and temperature rise. It does not seem beyond the limit of practical engineering to substitute some form of roller bearing for the present heavy grease or oil-lubricated bearings. A price recently quoted by a well-known roller bearing company was about 90*l.* for an 84-in. mill bearing, their estimate showing at least 90 per cent. saving in friction loss. As the light load losses of a mixing line may be 20 per cent. of full load, the heavy initial cost of roller bearings, if they can stand up to the work, does not appear to be prohibitive.

(To be continued).

NEW COTTON MILLS IN MANCHURIA.—According to the *Dairen Chamber of Commerce Journal* six new cotton mills are being erected in Manchuria, the largest of which will have 30,000 spindles. Assuming an average of 20,000 spindles per mill for the remaining five, the editor of the journal estimates that these factories will have an annual capacity of 107,250 bales of yarn and 2,502,500 pieces of cloth. Comparing these figures with the average annual imports of cotton yarn and cotton cloth through the three ports, Antung, Dairen and Newchwang, in the years 1916–20, it is considered that Manchuria will produce more yarn than she consumes when these factories are in operation.

THE EFFECT OF REPETITION STRESSES ON MATERIALS.*

By Professor F. C. LEA, D.Sc., M.Inst.C.E., M.I.Mech.E.

(*Concluded from page* 219.)

Optical Methods and Thermal Methods of Determining Fatigue Ranges.—Mr. Gough has described in ENGINEERING a method of determining fatigue ranges by means of a rotating mirror on the end of a revolving specimen. The author had used this method he believes before Mr. Gough, and also with the assistance of one of his students, Mr. H. P. Budgen, had developed the machine shown in Fig. 8. The machine, which has been entirely made in the Civil Engineering Laboratory of the University of Birmingham, is arranged to load a specimen as gradually as desired by means of the water tank T. The specimen is loaded as a cantilever through the ball bearing K, and the lever system shown. The best specimen to use is of the form shown in Fig. 6. This is rather expensive to make, but the hollow specimen has the advantage that when the specimen is loaded as a beam, the stress is much more nearly uniform than in the case of the solid specimen. All the results given by the cantilever machine and quoted in this paper have been obtained from hollow specimens. Solid specimens of several types are sometimes used; special collets are designed to grip these. Like other machines designed by the author, the number of repetitions is counted, and the machine stops automatically when the specimen breaks.

Fig. 7 shows the optical arrangements. A Pointolite lamp is fixed to the stand shown, and a mirror M is placed about 35 ft. away. A small pencil of bright light falls on this distant mirror, is reflected to the mirror M_1 on the end of the specimen, and then into a good telescope T. By this means load deflection curves for the specimen can be obtained. Such curves are shown in Figs. 9 and 10. For example No. 1, in Fig. 9, is the load-strain curve obtained from a specimen of 0·32 per cent. carbon steel. The first indication of a real departure from a straight line was at 13·81 tons per square inch. A specimen was then run as an endurance test at this stress for 6·4 million repetitions, and there was no indication of failure. A second load-strain curve, No. 2, was then run, and this indicated a departure from the straight line at 14·01 tons per square inch. Three specimens were then run at this stress and all broke after 51,000,000, 42,000,000 and 73,000,000 reversals, respectively. Perhaps No. 7 is still more striking. The real departure in this case seemed to be at 12·25 tons per square inch. It may be remarked here that on a first run many specimens indicated not a very good straight line, as though the running was eliminating slight inequalities in the specimen. This was peculiarly true for Armco iron. After the material had, however, been run into a cyclical condition the second load strain curve was much firmer. A specimen was run (see Table III) 137,000,000 repetitions at ± 12·25 tons per square inch range without fracture. Taking as another example No. 3, the definite departure was indicated at ± 14·6 tons per square inch. A similar specimen was then run at a stress of ± 14·8 tons per square inch for 9,000,000 reversals and then unloaded and re-loaded. The load-strain curve No. 4 now taken was more definitely straight than during the first loading of the specimen, inequalities had been worked out by the cycles run, and a stress of ± 15 tons per square inch was then indicated as about the fatigue range. Three specimens were then run at a stress of ± 15·1 tons per square inch; they ran 59,000,000, 51,000,000 and 46,000,000, respectively, before fracture. The history of other specimens is referred to in the note below Fig. 9. Again in Fig. 10, 13·81 tons per square inch was indicated as the fatigue range of No. 1 after a specimen had run 7,000,500 at ± 13·56 tons per square inch. One specimen ran 68·8 millions before fracture at this stress of ± 13·81 tons per square inch. Other specimens are referred to below the figure. A first run indicates then the safe critical range, while a second run indicates the stress at which the specimen will break if run continuously for, say, more than 40,000,000 repetitions. Table IV shows results obtained by a second loading and endurance ranges of specimens of steel that have been treated in different ways.

Haigh Machine.—Instead of using the cantilever machine, the Haigh direct tension and compression machine has been used. An extensometer which must be described elsewhere has been used to give load strain curves as the repetitions proceed. Such a load-strain curve as plotted on a sensitised plate is shown in Fig. 11. Forms of the wave from the alternate current machine working the Haigh are shown in Fig. 12. The results of repetition tests from the two machines are in practical agreement. In the Haigh machine it has been possible also to obtain an indication of the fatigue range by attaching thermo-junctions to the specimen. One example must suffice, although many could be given.

The first optical test on the cantilever machine indicated 13·81 tons per square inch for specimens of 0·14 carbon steel. The second loading indicated ± 14 tons per square inch, and three specimens ran respectively from 43,000,000 to 78,000,000 repetitions, at this range of stress, and then fractured. In the Haigh machine we obtained an indication of 13·90 tons per square inch on a second loading by the extensometer, and practically the same stress by a thermal method. Another specimen withstood, in the Haigh machine, 32·16 millions before fracture at a range of ± 13·9 tons per square inch.

Raising the Fatigue Limit by Cycles of Stress at Greater and Greater Ranges.—It is possible to change the fatigue range without raising the temperature of the specimen by running the specimens through cycles of stress of greater and greater range. Fig. 13 shows what has been done with a specimen of 0·32 carbon steel. It will be seen on reference to Table II that the actual endurance range of this steel is ± 14·2 tons per square inch. Now by running the specimen in the machine, Fig. 8, and very gradually increasing the load on the specimen to some stress and then unloading, it has been possible to obtain the somewhat remarkable result shown in Fig. 13. A specimen was run at a range of stress ± 18 tons per square inch, 42,000,000 repetitions before fracture occurred, whereas a specimen run straight away on a stress of ± 18 tons per square inch fractured after 12,580 repetitions. Thus cycles of stress at higher and higher ranges raise the fatigue limit. Comparing, however, No. 7 with No. 5, in Table I, it will be seen that both the gradual loading and the temperature have apparently effect in changing the fatigue limit. Also No. 9 of Table I was loaded direct to ± 16·75 tons per square inch. At the time of writing this has run 2,500,000 repetitions without fracture.

Microphotographic Method of Probable Fatigue Range.—In the Haigh machine a flat was polished on a specimen, and examined by a powerful microscope. The specimen was very gradually loaded and at each step several thousands of cycles were run. The machine was stopped and the specimen carefully examined. At the particular stresses indicated in Fig. 14 and Fig. 15, the machine was stopped after a few cycles. The structure appeared normal. Then 2,000 cycles were run and the specimen re-examined by the microscope. The slip bands had appeared. The specimen of 0·14 carbon steel, for example, was removed after being stressed at 12·36 tons per square inch, and the microphotograph of Fig. 14 taken. A similar specimen at a stress of ± 12·25 tons per square inch in the cantilever machine ran 137,000,000 without fracture, and a specimen was loaded to ± 12·58 tons per square inch in the Haigh machine and fractured after 38,000,000 repetitions. Similarly a specimen similar to that of Fig. 15 ran at a range of stress of

Fig. 7. DIAGRAMATIC OPTICAL SYSTEM.

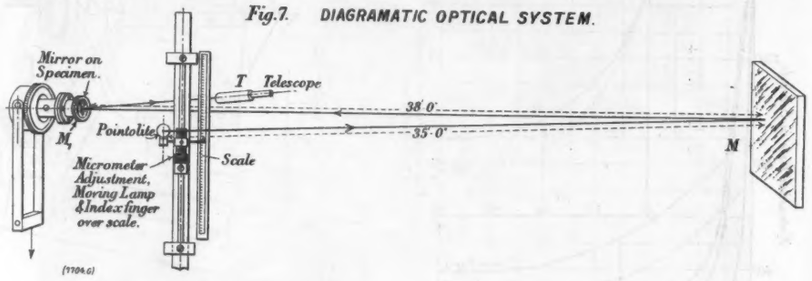
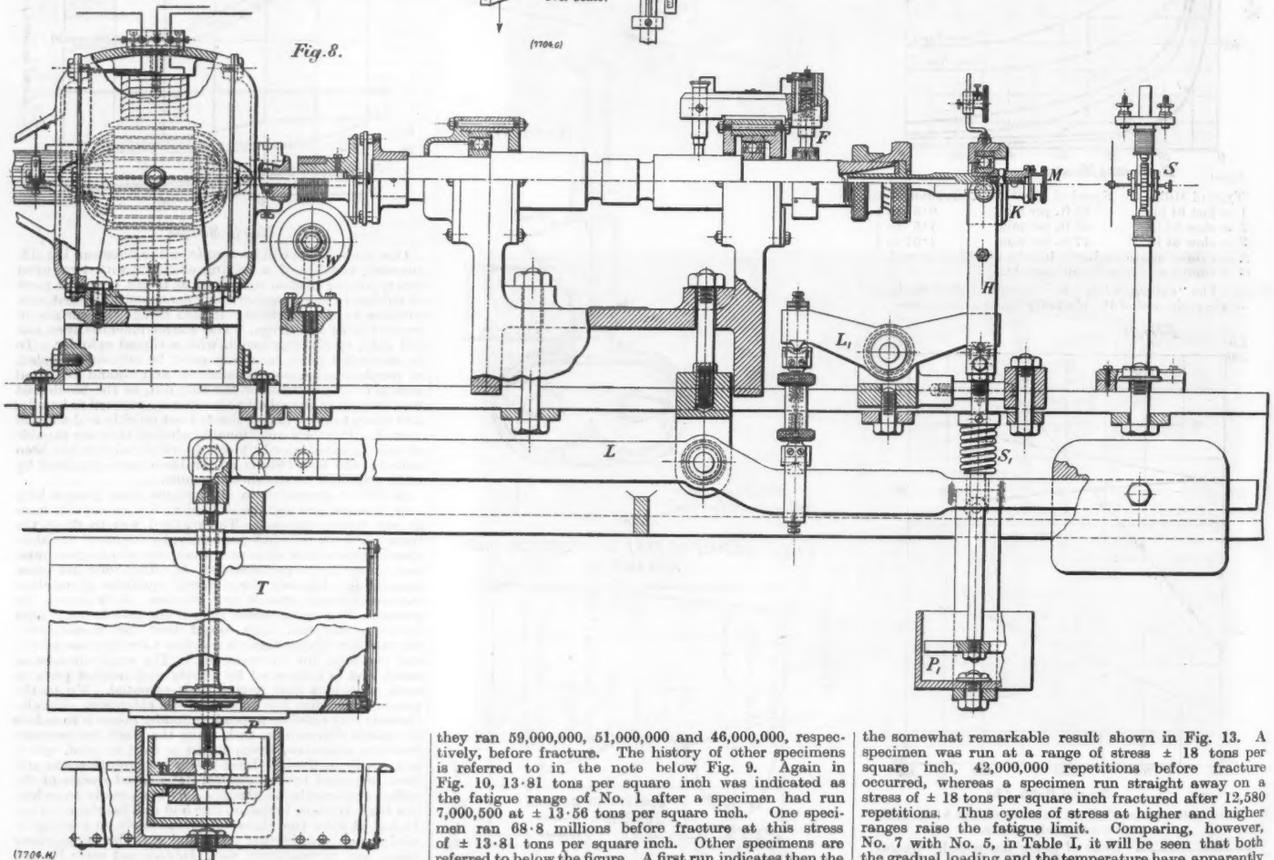


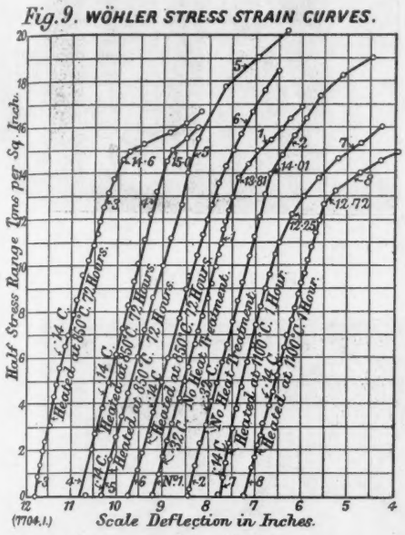
Fig. 8.



* Paper read before the Institution of Civil Engineers, Birmingham and District Association, February 8, 1923.

± 12·6 tons per square inch, 68,000,000 in the Haigh machine and fractured. Another specimen of 0·32 carbon steel which had been heated at 850 deg. C. for 36 hours was tested in the same manner. At ± 14·11 tons per square inch a definite thermal rise was noticed, and after 2,000 cycles the slip bands appeared. A similar specimen was then run at ± 14·11 tons per square inch for 73,000,000 reversals without fracture. Thus slipping can without doubt occur in these steels and be followed by healing, which prevents the specimen from breaking. This has been shown by the tests just described also by raising the fatigue range by gradually increasing the maximum stress while the specimen is

Fig. 9. **WÖHLER STRESS STRAIN CURVES.**



NOTE FOR FIG. 9.—*Curve* 1 is first loading.

Curve 2 is second loading giving an indicated fatigue limit at 14·01. A duplicate piece broke after 51,854,000 reversals at this stress.

Curve 3 is first loading.

Curve 4 is second loading, giving an indicated fatigue limit at 15 tons per square inch, at which a duplicate piece broke after 59,327,000 reversals at this stress.

Curve 5 was taken subsequent to three other loadings, all to maxima stresses of 18 tons per square inch.

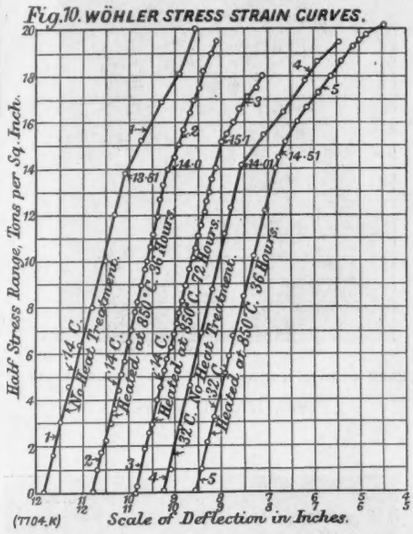
Curve 6 is final curve, in which fracture occurred.

Curve 7 is first loading.

Curve 8 is second loading giving an indication of 12·78 at which a duplicate piece broke after 55,450,060 reversals.

ductile materials break off quite short without showing any signs of elongation. What apparently happens is that, as the cycles of stress proceed, slipping occurs on certain planes, and then in or at the boundaries of certain crystals seizure occurs. Momentarily the cohesive

Fig. 10. **WÖHLER STRESS STRAIN CURVES.**



NOTE FOR FIG. 10.—*Curve* 1.—Second loading, of a sample previously stressed at 13·56 tons per square inch for 7·0005 × 10⁶ reversals, which then indicated a fatigue limit of 13·81 tons per square inch, at which a duplicate piece broke after 68,238,500 reversals.

Curve 2.—Second loading of a sample previously stressed at 13·8 tons per square inch, for 9·323 × 10⁶ reversals; which then indicated a fatigue limit at 14 tons per square inch, at which a duplicate piece broke after 43,280,000 reversals.

Curve 3.— Second loading of a sample previously stressed at 14·8 tons per square inch for 9·185 × 10⁶ reversals; which then indicated a fatigue limit of 15·1 tons per square inch, at which a duplicate piece broke after 59,327,000 reversals.

Curve 4.—Second loading of a sample previously stressed at 13·82 tons per square inch for 6·432 × 10⁶ reversals; which then indicated a fatigue limit of 14·01, at which a duplicate piece broke after 51,854,000 reversals.

Curve 5.—Second loading of a sample previously stressed at 13·7 tons per square inch for 7·34695 × 10⁶ reversals; which then indicated a fatigue limit of 14·51 tons per square inch, at which a duplicate piece broke after 78,310,000 reversals.

those sharp corners and cracks the actual stress may be much greater than the supposed mean stress, and thus for a double reason failure under repeated stress is likely to commence and occur at these points.

This is it that makes it so very difficult to account frequently for failure in practice. I have had a number of bolts from couplings and connecting rods to examine from time to time, that have been broken in service. Tensile tests have revealed no weakness, but microscopic or even naked-eye examination has not infrequently revealed slag inclusions or planes of separation, from which no doubt cracks have commenced and lead to failure. For this reason I often feel it is a great mistake to use wrought iron bolts in such cases. Steels are by no means free from these defects, but with care I think they can be more avoided than in wrought iron.

Factors of Safety.—In fixing working stresses, some fraction of the fatigue range must be taken, although in practice working stresses are frequently fixed as a certain fraction of the ultimate stress. As will be seen on reference to Table II, the total ± range of safe stress is not for steels very different from the statical breaking strength, and, therefore, whether the ultimate strength or fatigue is taken for many cases, it does not matter much, but there is danger in applying this to other metals. For steels the total ± range is nearly always equal to the ultimate stress, but in cases like duralumin and other alloys the range is only about two-thirds of the ultimate tensile strength, and in some cast alloys it may not be much more than one-half.

Conclusion.—Unfortunately, time and space has only allowed reference to fatigue tests with the range of stress equal in tension and in compression, and it also prevents further reference to other data gathered and other machines we have developed, but sufficient has been said to show that the apparent fatigue range of a material is not in reality a definite and fixed quantity. Like the statical breaking strength, it can be changed by a par-

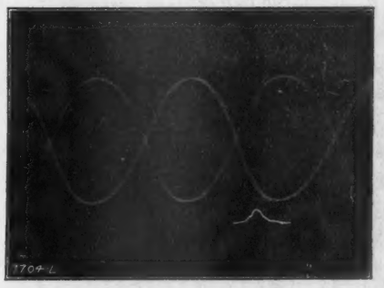


FIG. 11. STRAIN CURVE TAKEN ON PLATE MOVING AT CONSTANT VELOCITY FROM A SPECIMEN IN THE HAIGH MACHINE.

TABLE IV.

"A." First Fatigue Indication from Load-Strain Curves of previously Unstressed Samples.				"B." Endurance Test of Stresses from "A."				"C." F.—Indication from Load-Strain Curves of Samples Understressed as in "B."			Continuous Endurance of Stresses Indicated by "C."			
Carbon.	Sample Index.	Heat Treatment.	Indicated Instability from first Loading.	Sample Index.	Stress.	Reversals.	Result.	Sample Index.	Indicated Fatigue Range by Optical Method after the Reversals of Column 7.	Result.	Sample Index.	Stress.	Reversals.	Results.
			tons per sq. in.		tons per sq. in.							tons per sq. in.		
0·14	1	Heated for 36 hours at 850 deg. C.	13·8	3	±13·8	8·323 × 10⁶	Unbroken	3	14·0	Unbroken	5	14·0	43·28 × 10⁶	Broke.
											5_1	14·0	59·99 × 10⁶	Broke.
											5_2	14·0	78·52 × 10⁶	Broke.
0·14	2	Heated to 1100 deg. C. for 1 hour	12·25	4	±12·25	11·886 × 10⁶	Unbroken	4	12·69	Unbroken	10	12·69	52·55 × 10⁶	Broke.
											10_1	12·69	55·45 × 10⁶	Broke.
											10_2	12·69	31·002 × 10⁶	Broke.
0·14	6	No heat treatment ..	13·56	8	±13·56	7·0005 ×10⁶	Unbroken	8	13·81	Unbroken	11	13·81	68·2385 × 10⁶	Broke.
											11_1	13·81	59·6 × 10⁶	Broke.
											11_2	13·81	40·25 × 10⁶	Broke.
0·14	7	Heated for 72 hours at 850 deg. C.	14·6	9	±14·8	9·185 × 10⁶	Unbroken	9	15·1	Unbroken	12	15·1	59·327 × 10⁶	Broke.
											12_1	15·1	51·12 × 10⁶	Broke.
											12_2	15·1	45·75 × 10⁶	Broke.
0·32	A	Heated for 36 hours at 850 deg. C.	13·70	C	±13·70	7·34695× 10⁶	Unbroken	C	14·51	Unbroken	E	14·51	78·31 × 10⁶	Broke.
											E_1	14·51	65·85 × 10⁶	Broke.
											E_2	14·51	40·58 × 10⁶	Broke.
0·32	B	Heated to 1100 deg. C. for 1 hour	11·88	D	±11·88	7·0022 ×10⁶	Unbroken	D	12·21	Unbroken	F	12·21	81·565 × 10⁶	Broke.
											F_1	12·21	31·65 × 10⁶	Broke.
											F_2	12·21	74·61 × 10⁶	Broke.
0·32	H	No heat treatment ..	13·82	J	±13·82	6·432 × 10⁶	Unbroken	J	14·01	Unbroken	K	14·01	51·584 × 10⁶	Broke.
											K_1	14·01	42·15 × 10⁶	Broke.
											K_2	14·01	73·52 × 10⁶	Broke.
0·32	G	Heated for 72 hours at 850 deg. C.	14·6	I	±14·5	7·58 × 10⁶	Unbroken	I	14·6	Unbroken	L	14·6	60·036 × 10⁶	Unbroken.
											L_1	14·6	58·2 × 10⁶	Broke.
											L_2	14·6	32·35 × 10⁶	Broke.

running, and also by heating as described above. No. 2 of Fig. 2 shows that a statical test would probably have shown considerable slipping at quite low stresses, but it is very doubtful indeed whether a repetition stress test would have shown slipping. Copper and certain alloys show load strain curves at ordinary temperatures like No. 2 of Fig. 2.

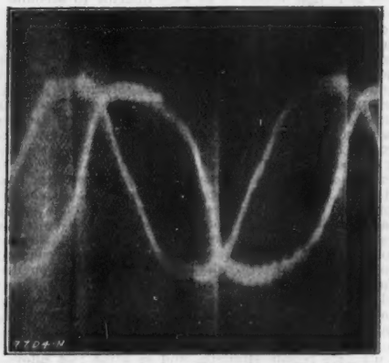
Mode of Failure, and the Effect of Hair Cracks and Slag Inclusions.—In all cases of fracture by fatigue in tension and compression, or by bending, the most stresses break down, but the movement is not sufficient to cause a real crack, and healing may take place. If the stresses exceed a certain amount, however, a crack finally develops and failure is then only a matter of time. Now, suppose there is a segregation of some kind in the metal, or there is a hair crack, or a slag inclusion, or a plane of cleavage caused by oxidisation, or other cause, then a crack has already started before stressing, and healing cannot take place. Again, if there are sharp corners or cracks in an element, it can be shown that at

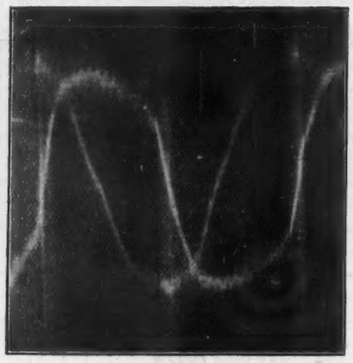
ticular history. For example, the breaking strength of steel can be very greatly raised by cold work. The author has shown elsewhere* that the ultimate strength, the limit of proportionality, and other properties of such steels, can also be changed by heat treatment.

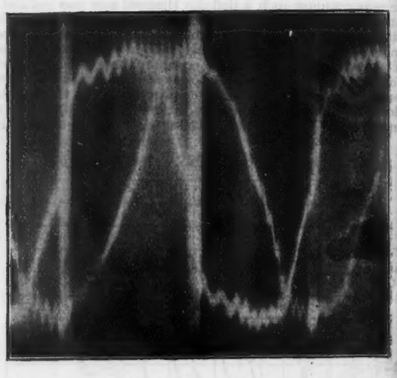
So the fatigue range of steel can be raised by running the specimen through cycles of stress of increasing range,

* "Recent Researches in Steel Tubes," Admiralty. "Aeroplane Materials," Jenkin.

THE EFFECT OF REPETITION STRESSES ON MATERIALS.







Oscillograph Curves taken from the Haigh Alternator.

Fig. 12a. 60 Volts. Fig. 12b. 65 Volts. Fig. 12c. 75 Volts.

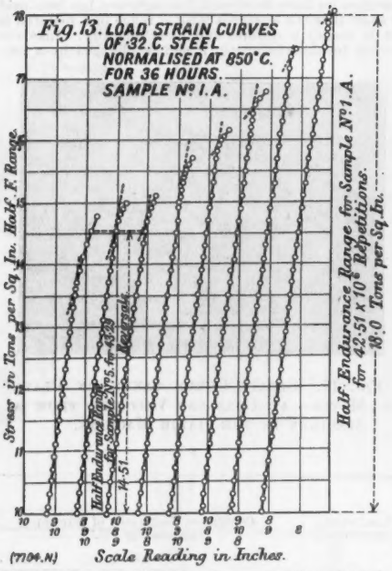


Fig. 13. LOAD STRAIN CURVES OF 32 C. STEEL NORMALISED AT 850°C. FOR 36 HOURS. SAMPLE No 1. A.
Stress in Tons per Sq. In. Half R. Range.
Half Endurance Range for Sample No 1. A. for 42·51 × 10⁶ Repetitions. 18·0 Tons per Sq. In.
Half Endurance Range for Sample No 5. for 43·28 × 10⁶ Repetitions. 14·51
Scale Reading in Inches.

Note for Fig. 13.—Piece No. 1a was repeatedly loaded and unloaded, to finally indicate 18 tons per square inch. This stress was then endured by the same sample for 42·51 × 10⁶ repetitions.
A duplicate, 2a, was directly stressed to 18 tons per square inch, but failed after 12,580 reversals.
A duplicate, No. 5, endured 14·51 tons per square inch for 43·28 × 10⁶ repetitions before breaking.
The unloading curve is not shown.
The rate of loading was constant at 0·3 tons per 2,000 cycles. The curves are shown only plotted above 10 tons per square inch.

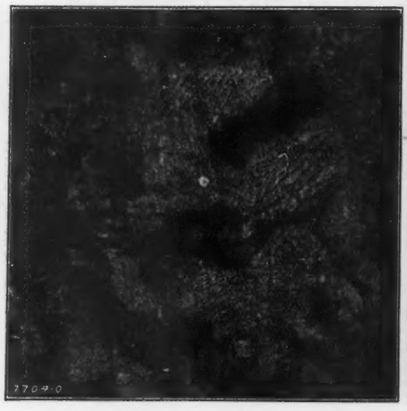


Fig. 14. Haigh Axial Test.

Sample 4a.—14 C. heated to 1100 deg. C. for one hour. Slip lines first formed at a first stress causing a thermal rise at 12·36 tons per square inch. Mag. 150 diams.

Fig. 15. Haigh Axial Test.

Sample Da.—32 C. heated to 1100 deg. C. for one hour. Slip lines first formed at first stress causing a thermal rise at 12·05 tons per square inch. Mag. 150 diams.

during which slipping of the crystals that takes place evidently heals and allows a higher and higher stress to be reached before cracking takes place. Also heating the specimen has somewhat the same effect, and apparently allows the material to heal as rapidly as it breaks down. To obtain the fatigue range by endurance tests it is, therefore, best to load the material first with a range of stress higher than the real fatigue range, so that fracture is sure to take place. Then by lowering and lowering the stress of consecutive specimens, the stress at which, say, 10,000,000 repetitions can be run, will give within a few per cent. the real fatigue range, at any rate of steels.

The fatigue limit for certain metals can, however, be quickly obtained by optical means, but the tests require great care and the specimen should not be overstressed and then tested. The materials for these tests have been supplied by the Engineering Research Board of the Department of Scientific and Industrial Research, to whom the author is indebted. He also wishes to express his great indebtedness to Mr. H. P. Budgen, M.Sc., for his enthusiastic assistance in carrying out the researches described in this paper.

CATALOGUES.

Second-Hand Machinery.—Messrs. George Cohen, Sons and Co., 600, Commercial-road East, London, E., send a copy of their current list of second-hand machinery, engines, boilers, joists, girders and other material.

Concrete Flooring.—A system of constructing concrete floors without erecting timber shuttering, is described and illustrated in a special catalogue issued by Messrs. J. and W. Stewart, 12, Berkeley-street, London, W.

Electrical Plant for Gas Works.—The Allgemeine Electricitäts Gesellschaft, Berlin, send an illustrated booklet of 130 pages in German text describing a large variety of electrical plant made by them, for use in gas works.

Brakes and Clutches.—Messrs. Ferodo, Limited, Chapel-en-le-Frith, Derbyshire, have issued price lists of fibre and bonded asbestos lining for brakes and clutches, in heavy or light grades, and suitable for colliery and general engineering work.

Steel Construction.—Fencing, staircases, window frames, building frames, engine platforms, suspension bridges and similar work are represented in a priced catalogue, issued by Messrs. David Rowell and Co., Limited, 14, Howick-place, Westminster, London, S.W.

Ship Construction.—A system of hull construction providing clear spaces, easy access for cleaning and also giving great longitudinal strength, is described in a special catalogue received from the Millar System of Ship Construction, Limited, 59, Mark-lane, London, E.C.

Shop Fittings.—A very complete range of roll-up shutters, extensible gates, shop front framing, sign letters and various accessories and materials used in shop fitting work, are shown in a catalogue issued by Messrs. S. W. Francis and Co., Limited, 64, Gray's Inn-road, London, W.C.

Turbo-Generators.—A catalogue of small turbo-electric generator sets with capacities of 5 kw., 7½ kw., 10 kw. and 15 kw., is to hand from the Westinghouse Electric and Manufacturing Company, East Pittsburgh, U.S.A. These small turbines, we believe, are extensively used in the United States for marine and industrial lighting and other applications.

Switch Gear.—We have received from the British Thomson-Houston Company, Limited, Rugby, a descriptive catalogue of direct-current switchboard panels for pressures up to 660 volts, and lists of drum-type controllers and resistances for direct-current and alternating-current circuits. The catalogues give very full particulars arranged in an orderly and convenient manner for reference.

Boiler-Making Machines.—A catalogue of machines used by boiler makers has come to hand from Messrs. Henry Berry and Co., Limited, Leeds. Illustrations with some descriptive matter are given of a variable power hydraulic flanging and forging press; other hydraulic presses of bridge and open-side types for forging and flanging; plate-bending rolls for plates up to 18 ft. wide and 1½ in. thick; a vertical machine for bending plates up to 2½ in. thick by pressure between curved dies and capable of forming a single plate into a complete cylinder; a rotary flanging machine to which a slide rest for turning may be added; and various fixed and portable riveting machines. The catalogue also deals with heavy pumps, accumulators and hand-operated portable testing pumps.

Water Fittings.—A strongly-bound catalogue of over 550 pages quarto has come to hand from Messrs. Glenfield and Kennedy, Limited, Kilmarnock. It includes particulars of a vast range of pipes and fittings, and a great variety of valves and accessories of all kinds, such as measuring, indicating and testing instruments and machines; casings, boxes and enclosures for protection; and special tools for fitting up and overhauling. The storage and distribution of water, &c. which forms one of the most important features of social and industrial life, are subject to damage and interruptions from which no excellence of construction can completely eliminate. They involve, therefore, a system of repair and maintenance under a great variety of conditions, and the catalogue provides those responsible for such work with a fully-detailed illustrated list of the materials they may require, with much useful data of a technical kind. The illustrations, tables of sizes, weights, capacity, &c., are very complete, and the catalogue will be of extreme value and convenience to engineers. There is an alphabetical index to the contents and a numerical index to the various sections.